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THE CORN-CANNING INDUSTRY.

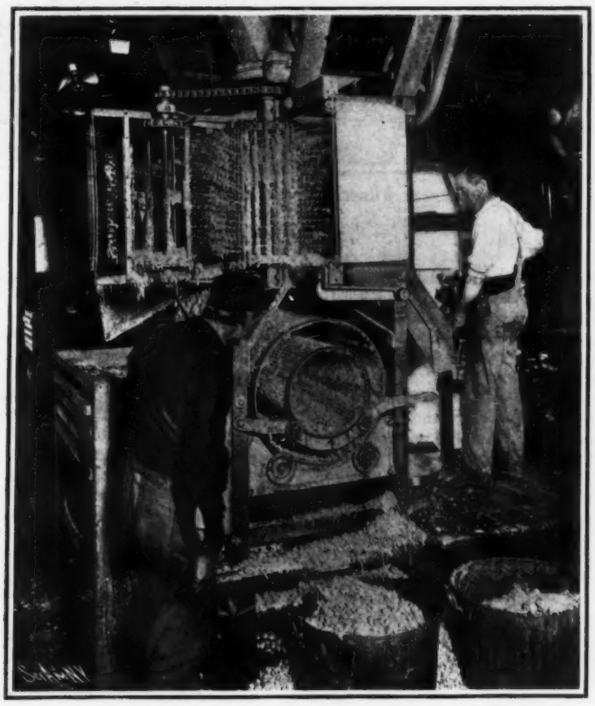
SMALL indeed is the number of the industries that are more closely identified with the progress of the United States, almost from its inception as a nation, than that of preserving foods by hermetic sealing, universally known under the generic title of "canning." Taking its beginning on this side of the Atlantic output of over 700,000,000 cans, valued at something like $82,000,000. Aside from the market that it has made for agriculture, and without reference to the consequent industries of manufacturing and delivering canning machinery and supplies, the business to-day requires the labor, during the height of the season, of at least 400,000 people.

of refrigeration, canning is the only one of these methods which preserves the article with the retention of the greater part of its flavor and natural texture; and unless great care is exercised in the thawing, refrigerated foods are not palatable. Prior to 1795 the only methods of this character generally employed were those involving the use of salt and sugar

THE MACHINE WHICH AUTOMATICALLY FILLS THE CANS.

MECHANICALLY SOLDERING THE TOPS UPON THE CANS FILLED IN THE PREVIOUS OPERATION.

CUTTING THE GRAINS OF CORN FROM THE COBS. THE EARS HAVE BEEN PREVIOUSLY HUSKED AND SELECTED.



THE SILKING MACHINE WHICH REMOVES STRAY BITS OF SILK OR COB.

THE CORN-CANNING INDUSTRY.

Shortly after the end of the eighteenth century, the art has paralleled the general advancement of the country, almost step for step, and to-day, despite our modern methods of storage, refrigeration, and transportation, it has assumed proportions that are little short of astounding. Particularly rapid has been its growth during the last half century. In 1900 there were over 2,000 canned-goods packing firms engaged in the business in the United States, with an annual

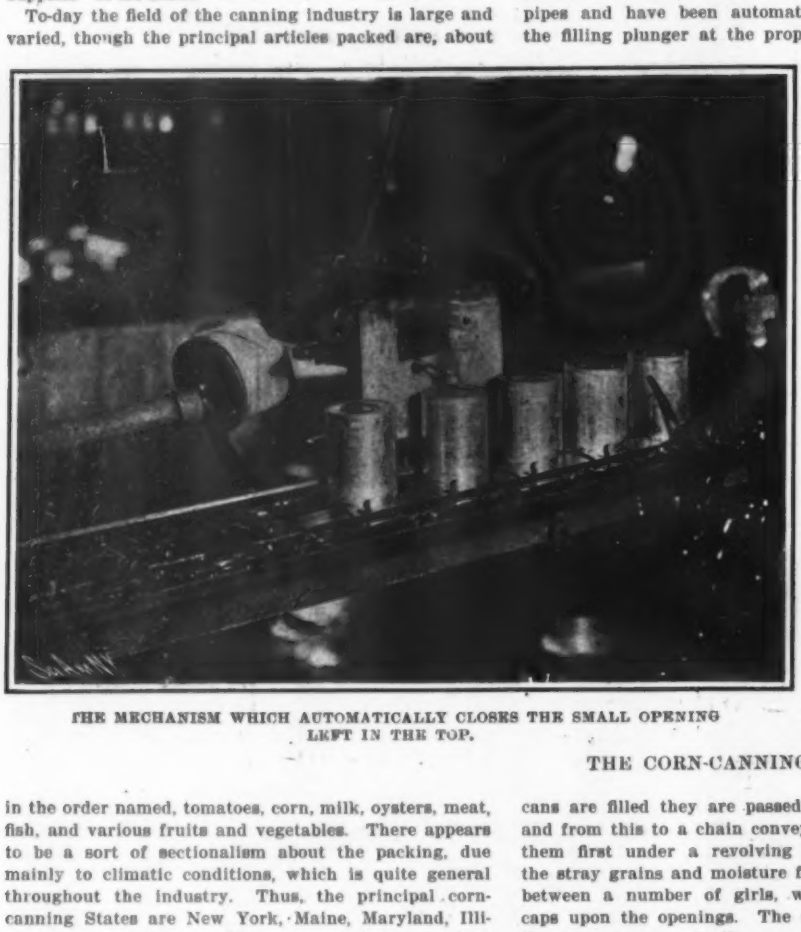
Since the very earliest times of his history, man has consistently made attempts to preserve articles of food from deterioration or putrefaction, in order to overcome the limitations imposed by the seasons and localities. The action of the "ferment" of decomposition may be neutralized by desiccation, the use of antiseptics, and more recently refrigeration and canning, these being the known processes for killing the organism or precluding its presence. With the exception

or drying. At this time, during the throes of the French Revolution, Nicholas Appert, a Frenchman who had spent most of his life in the business of food preparation and preservation, advanced a method which is fundamentally that used in the canning industries to-day. Substantially, this was to inclose fruit in a glass jar, which was then corked and subjected to the action of boiling water for a period varying according to the nature of the article treated,

Appert was stimulated in his work through the offer of a reward by the French government for a method of food preservation to be used in naval supplies, and fourteen years later the French Ministry, under Napoleon the Great, awarded him this prize of 12,000 francs. His method was used in factories in England about the year 1810, and it is believed that it was introduced into that country directly from France with the assistance of English capital. In this year, too, an English patent was issued to Peter Durand, who devised a system of food preservation involving the use of the tin-plate can. The industry was begun in this country some few years later by Ezra Daggett, who acquired his knowledge in an English cannery, and subsequently emigrated to America. Since then the growth, slow at first, has been consistent and at times even extraordinarily rapid, and to-day we find it applied not only to the sea food upon which Daggett started his work, but also to nearly every other kind of edible.

At the present time the various processes involved in the canning industry are almost entirely performed by machinery, the growing importance and magnitude of the business bringing with it the invention of innumerable labor-saving devices and machines, which have materially cheapened the product and increased the scope of the manufacture. The accompanying illustrations give a fair idea of the ingenious character of some of the machinery employed. Simultaneously there has arisen a great business dealing in "packers' supplies" of all kinds.

To-day the field of the canning industry is large and varied, though the principal articles packed are, about



THE MECHANISM WHICH AUTOMATICALLY CLOSES THE SMALL OPENING LEFT IN THE TOP.

THE COOKING VATS. HERE THE SEALED CANS ARE COOKED BY MEANS OF STEAM UNDER PRESSURE.

THE CORN-CANNING INDUSTRY.

in the order named, tomatoes, corn, milk, oysters, meat, fish, and various fruits and vegetables. There appears to be a sort of sectionalism about the packing, due mainly to climatic conditions, which is quite general throughout the industry. Thus, the principal corn-canning States are New York, Maine, Maryland, Illinois, Iowa, and Kansas. The accompanying engravings are illustrative of the industry as carried on in one of the larger of the up-State New York packing establishments. The canning of corn was begun simultaneously in two canneries during the year 1839 in Baltimore, Md., and Portland, Me., the latter being under the management of Mr. Isaac Winslow, who was subsequently granted letters patent covering a method for preserving green corn which in itself differs little from the regular Appert process involving hermetic sealing. Since then the preservation of sugar corn by packing in air-tight cans has become one of the most important phases of the entire industry, and to-day involves many interesting mechanical processes, though fundamentally it differs little from the earlier art.

As carried out to-day, the husks are removed from the ears of corn by hand, and the latter are placed upon a belt conveyer which travels in a wooden trough. A number of women are stationed along this trough, and as the corn passes by they break off the tips or ends, pick out the malformed ears, or otherwise remove the useless or harmful from the others. The raw material is then carried to a chute leading to the cutting machine, in which the grains are separated from the cobs. The ear is passed into the cutting machine by hand in the longitudinal direction of a species of cylindrical casing which contains the sets of blades, two horizontal and two vertical, which shear the grain from the cob. These blades fit themselves to the size of the ear by means of adjustable actuating rods. The grains of corn and the juice drop through a chute underneath the casing into a trough, in which they are removed to the silking machine by means of a spiral screw conveyer, while the cobs leave the ends of the casing and fall upon a belt conveyer which carries them off.

The silking machine shown in the fourth photograph is for the purpose of removing the silk and bits of husk or cob which may be mingled with the grain. The corn enters a casing containing a number of fixed, projecting rods with a series of moving rods passing between the former, so that as the grains fall toward the lower end of the machine, these rods draw out and separate the silk or fragments of husk. After passing through these rods, the corn enters two wire-net cylinders, revolving one within the other in opposite directions, where the pieces of cob are removed, the grains falling through the meshes of the netting. Then the corn is drawn from a pan underneath the cylinder, raked into tin basins, and carried to the machine which fills the cans.

This is illustrated in the first engraving, and consists substantially of a cylinder containing the corn, to which the proper quantity of its natural juice has again been added, and which is heated to a constant temperature of 180 deg., and a pair of incased plungers located underneath the large cylinder. These plungers in alternation draw a certain measured quantity of the material from the cylinder, and force it into the cans, which have passed down vertical pipes and have been automatically stationed before the filling plunger at the proper moment. After the cans are filled they are passed onto a rotating plate, and from this to a chain conveyer. The latter carries them first under a revolving brush, which removes the stray grains and moisture from the tops, and then between a number of girls, who properly place the caps upon the openings. The can is then carried by the same conveyer to the cap-soldering mechanism.

This ingenious machine is shown in the following illustration. The cans, in line, pass alongside the rear of the machine (as seen in the photograph), first passing underneath a revolving series of individually revolving brushes, which spread a quantity of liquid flux around the edge of the cap to be soldered. When a series of cans, to the number of about a dozen, has in this manner been provided with flux, the whole row is automatically forced under a framework, each can sliding between cleats which lie at an angle, and which center it beneath the soldering iron. These irons are round in shape, and correspond in size to the caps. They are internally heated by individual gas flames, have a rotating movement, descend upon the cans as soon as these are in position, and rise again when the operation of soldering is completed. The series of cans is then pushed from between the cleats upon a chain conveyer by the following series to be soldered. The work of this machine is naturally closely watched, and where necessary supplemented by hand soldering in the case of imperfections in individual cans.

The cans are now carried by the conveyer to the machine shown in the first engraving above, which closes the small hole left in the cap to permit the escape of the steam or vapor generated in the vessel. The cans, as they approach the soldering iron, are held in place upon the conveyer by means of an additional chain with retaining fingers. The pointed iron, which is internally heated by gas and against which the long, thin strap of solder is automatically fed, descends upon the hole in the cap, is held there a moment, following the traveling can, rises, and descends upon the succeeding one with an ingenious step-like motion.

The cans, to the number of two hundred or more, are placed in large, cylindrical baskets made of strips of iron. These baskets are then let down into cylindrical iron cooking-vats, which are provided with means for tightly clamping on the heavy lids, with thermometers, pressure gages, safety valves, etc., as shown in the engraving. The corn is cooked in these vats for a period of eighty minutes at the temperature of steam at a comparatively low pressure. At the end of this time the retaining basket is mechanically lifted from the cooker and placed upon a conveyer, which carries it into and through a large tank of cold water in order to cool the cans; then by means of an overhead trolley system the baskets are removed to the storage warehouse, where the cans are labeled and packed, and kept until required for the market.

POTTERY PRODUCTS OF THE UNITED STATES.

THE total value of the pottery products of the United States in 1907, as reported to the statisticians of the United States Geological Survey, was $30,143,474—a decrease of $1,297,410, or 4.13 per cent, from the value in 1906. Compared with the figures for 1905, however, those for 1907 are much larger, showing a gain of $2,224,580, or 7.97 per cent, and the value of the 1907 products is more than twice as great as that of the pottery made in 1898.

As in former years, pottery products, except earthenware and stoneware, were reported from but few States in 1907. White ware, or what is known as "general ware," was produced, as in 1906, in nine States, sanitary ware in seven States, and porcelain electric supplies in nine. Red earthenware, the commonest of the pottery products, which can be made from almost any red-brick clay, was reported from thirty-two States.

Rank of the States.—Ohio was the leading pottery producing State, with wares valued at $13,533,199, or 44.90 per cent of the total. This is a decrease of $457,160, or 3.27 per cent, from the value of the wares in 1906, which was $13,990,359, or 44.50 per cent of the total. In 1905 the value of the Ohio wares was $13,024,071, or 46.65 per cent of the total.

New Jersey was second in rank in 1907, with wares valued at $6,985,626, or 23.18 per cent of the total, as compared with a value of $7,282,658, or 23.16 per cent of the total, for wares produced in 1906.

West Virginia, fifth in rank in 1906, passed both New York and Pennsylvania and became third in 1907, with wares valued at $2,159,132, or 7.16 per cent of the total, as compared with wares valued at $1,588,555, or 5.05 per cent of the total, in 1906—an increase in 1907 of $570,577, or 35.92 per cent.

New York was fourth in both 1906 and 1907, the value of the product in the latter year being $1,934,498, a gain of $66,151, or 3.54 per cent.

Pennsylvania, which was third in 1906, with wares valued at $2,410,817, was fifth in 1907, the value of the wares decreasing to $1,309,878, a loss of $1,100,939, or 45.67 per cent.

Great Pottery Centers.—The two leading pottery States—New Jersey and Ohio—produced in 1907 more than 68 per cent of the pottery of the entire country. In New Jersey 93.32 per cent of the total for the State was made in Trenton; in Ohio the great pottery center is East Liverpool, but its proportion of the State's total in 1907 was much less than that of Trenton, being but 42.33 per cent. In 1906 these cities produced, respectively, 93.25 per cent and 43.98 per cent of the State totals. Together the two cities produced 40.63 per cent of the value of the pottery for the whole country in 1907, Trenton contributing 21.63 per cent and East Liverpool 19 per cent.

Value of Products of Different Classes.—The wares known as "C C," "white granite," "semi-porcelain," and "semi-vitreous porcelain," representing the general household wares and composing the bulk of what is known as "pottery," are from a monetary standpoint the most important pottery products of this country, their value amounting in 1907 to $13,913,680. As compared with the value of these products in 1906, this is a decrease of $238,823, or 1.69 per cent; it is, however, a gain of 5.43 per cent over the value of such wares produced in 1905. Ohio was the leading producer, reporting wares valued at $9,419,960, or 67.70 per cent of the whole. West Virginia stood second, with wares valued at $1,651,732, and New Jersey, which held second place in 1906, was third in 1907, with products valued at $1,225,691.

The most interesting of the pottery products—china, including bone china, delft, and belleek ware—showed a slight increase in value, from $1,787,776 in 1906 to $1,930,669 in 1907, a gain of 7.99 per cent. As in previous years, these products were reported from but four States, with New Jersey at the head and New York second. These States produce nearly all the china made in this country.

Red earthenware was reported from thirty-two States, with Massachusetts at the head, Pennsylvania second, and Ohio third in value of products. In 1906 Ohio stood first, Massachusetts second, and Pennsylvania third. The total value of this ware in 1907 was $845,465, as compared with $909,262 in 1906—a loss of $63,797, or 7.02 per cent. As compared with the value of the product in 1905, however, the 1907 value is greater by $64,828, or 8.30 per cent.

Stoneware and yellow and Rockingham wares were reported from thirty States in 1906 and from twenty-nine in 1907, Montana dropping from the list. Ohio was the leading producer, reporting in 1907 wares valued at $1,648,213, or 38.5 per cent of the whole. Illinois was second and Pennsylvania third in both years. The total value of these products in 1907 was $4,280,601, a gain over the value in 1906 of 2.07 per cent.

Sanitary ware and products of the porcelain electric supply branches of the pottery industry, being used almost exclusively in construction, showed a decline in value as the result of the decrease in building operations. The output of sanitary ware in 1907 came from seven States, the value amounting to $4,863,222. Of this total 74.35 per cent was reported by New Jersey. Indiana was second and West Virginia third in production. The value of the porcelain electric supply products in 1907 amounted to $2,613,771—a decrease of 7.91 per cent when compared with the value of the products in 1906, but a considerable increase over the value of the products in 1905, a year of great prosperity.

Imports, Exports, and Consumption.—The pottery imports into the United States in 1907 were valued at $13,585,612 and the domestic production at $30,143,474, a total of $43,729,086. After deducting the exports (domestic $1,131,641 and foreign $36,538), there appears to have been a net consumption of pottery products valued at $42,560,907, of which the domestic production was 70.82 per cent, as against 72.26 per cent in 1906. Although the proportion of domestic production to consumption declined slightly in 1907, its trend in previous years has been steadily upward, and it will no doubt continue to increase until the domestic potter will supply the demand for the higher grades of his wares as he now supplies that for the lower grades. The general tendency in quality of domestic pottery is undoubtedly upward, and the fact that there was a marked advance during 1907 in the production of distinctively American china augurs well for the future of the industry.

A statistical report on the clay-working industries of the United States, prepared by Jefferson Middleton, of the United States Geological Survey, has just been published by the Survey as an advance chapter from "Mineral Resources of the United States, Calendar Year 1907." Copies of this report may be obtained by applying to the Director of the Survey at Washington.

The total production of petroleum in the United States for 1907 is reported as amounting to 166,095,335 barrels, or 22,149,862 metric tons. This shows an increase of 39,601,399 barrels over the production of 1906. The amount of this increase is greater than the total production of petroleum in any year up to 1889.

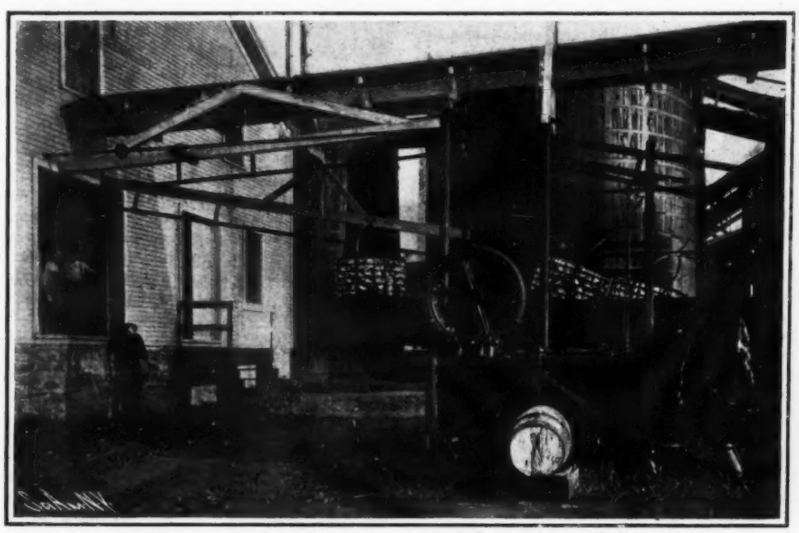
COLOR ANALYSIS OF ILLUMINANTS.

ONE of the most suggestive papers at the Philadelphia convention of the Illuminating Engineering Society was that by Dr. Ives on work with the colorimeter. The instrument is in effect a color mixing box with which a given source of light can be matched against a known mixture of supposedly primary red, green, and blue. We say supposedly, since in this particular instrument the colors are derived from colored screens of which the red and blue are rather less pure than the green, and there is a chance that some of the apparent anomalies found in the results may be due to this cause. Color mixture for such purposes has generally been done with red, green, and blue cut out of the prismatic spectrum, requiring rather unwieldy apparatus—a difficulty which the present instrument avoids. Unless a prismatic color box be of large dimensions there is danger that the selecting slits as they are opened may shift the mean wave length materially. In the colorimeter used by Dr. Ives this cannot occur, but one depends on the correctness of the mean wave length transmitted by the screens, which may be considerably modified by the varying physiological effects as the intensities vary. In other words, the sensibility of the eye for color in faint illumination enters as a disturbing factor since the extent of spectrum admitted by the screens is sufficient—especially at the two ends of the spectrum—to permit material shifts in the point of dominant physiological effect. There is also a chance that the blending device which depends on persistence of vision may produce some modifications.

We make these suggestions not in any spirit of criticism of what is really a most interesting piece of research, but because the outstanding differences in results obtained by the colorimeter by the prismatic color box are so important as to demand thorough investigation and explanation of methods. Dr. Ives obtains for a gas flame the following proportions: Red, 100; green, 40; blue, 5.8. Sir William Abney working with prismatic colors obtained for a gas flame: Red, 100; green, 95; blue, 27. In other cases the results are similarly divergent, Dr. Ives's figures being apparently very much lower in the green and blue than Sir William Abney's, in the terms in which the two sets are given. This difference in the figures is completely changed if one remembers that Dr. Ives's readings are given in an arbitrary scale of red, 100; green, 100; blue 100 instead of on Abney's percentage scale; but the data continue irreconcilable when due allowance is made for this. Part of the outstanding difference may be charged up to a difference in the conception of daylight, for which, whatever it may be, the colorimeter scales read: Red, 100; green, 100; blue, 100. One must therefore go very cautiously in comparing Dr. Ives's figures as they stand with those obtained by other experimenters and other methods, while barring the physiological difficulty of which we spoke, they may be fairly compared with each other. The case in which they are liable to come to grief is that in which the illuminant investigated lacks conspicuously one of the primary colors, but is strong in more or less adjacent radiations which the screen lets through.

Looking now at Dr. Ives's figures as given, and remembering that they show not absolute percentages but percentages of the component rays taken separately and referred to an arbitrary standard, one can derive from them much that is of value. The one fact that stands out most conspicuously is the similarity of all the simple incandescent bodies, including flames, until one comes down to the Hefner lamp. There are, however, some anomalies even in this list. Does Dr. Ives wish to be understood as holding that the tantalum lamp has selective radiation for the green as compared with the graphitized filament carbon lamp? Of course, tantalum doubtless may vary from black body radiation, but if it is thus selective the fact is certainly very curious. On the other hand, the ordinary Welsbach mantle, which is known to have strong selective radiation for the green, appears in the list as standing next to the electric arc and the Moore CO_2 tube in approximation to daylight, and, wonderful to relate, the mercury arc falls into line even ahead of the trio just named. Now we have had white defined successively as just the color of several recently exploited illuminants, but we were not aware that even the best friend of the mercury arc ever claimed it to be a good understudy for daylight. Is there not something radically wrong with a rating so at variance with what the eye sees? This question is no reflection on the general accuracy of the experimental work as such. It reaches further, even into the inquiry as to whether any color match against the primary colors can be made to give the visual value of the color unless in the case of non-selective radiation. And the answer to this must be broadly in the negative. Without going into fine distinctions, the color box color and the visual color can agree only when the colors that are transmitted by the three slits or screens are normal samples of the spectrum as a whole.

The eye integrates the spectrum as a whole according to its luminosity curve, while the color box attempts to integrate it by reference to the three primary sensibility curves. Within certain limits the two agree, while beyond these limits they apparently do not, as might indeed well be expected. The result is that a freakish spectrum may give a visual effect nearer to or further from white than the color box would indicate. Color matching tests throw some light on the subject. Like color-box tests, they are fairest when the lights compared give ordinary spectra. In the case of discontinuous spectra the relative results depend on the colors chosen. It would not be a difficult matter to select dyes that would suit an illuminant of any given type and make it seem reasonably near to daylight in its effects. Thus it is only too plain that even the most carefully planned methods of estimating color values of illuminants are liable to give unreliable results when discontinuous or abnormal spectra are concerned. Perhaps the most sensitive test is to illuminate sheets of plain white cardboard by the lights to be compared. The eye is very keen to perceive small differences of tint, and one can say quite definitely whether one sheet is bluer or pinker or greener than another. It is the quantitative measurements that give trouble. And the chief difficulty after all is to settle on a normal white as a standard of reference. Dr. Ives shows in his paper the astonishing discrepancies in the color values of daylight or of sunlight. Until there is some agreement as to what shall be called white, there may well be trouble enough in defining the colors of artificial lights. What we here wish particularly to emphasize is that color-box tests, however carefully made, are not satisfactorily comparable with each other for various reasons, particularly the lack of a common standard; that they do not give satisfactory results with discontinuous or abnormal spectra; and that even color-matching tests are uncertain, unless one is sure that the colors do not favor one source above another.—Electrical World.



COOLING THE CANS AFTER COOKING AND TRANSPORTING THE SAME TO THE STOREROOMS.

THE CORN-CANNING INDUSTRY.

THE LODGE "B" SPARK HIGH-TENSION IGNITION.

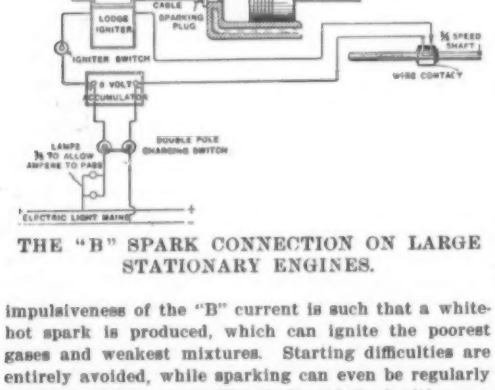
A NEW TYPE OF IGNITION SYSTEM.

An important development in connection with electric ignition, both for automobiles and for stationary internal-combustion engines, has been effected by the evolution of a new type of ignition system, by Sir Oliver Lodge. In the ordinary type of high-tension ignition with accumulator and coil, the ends of the secondary winding are connected direct to the sparking plug. The troubles incidental to the ordinary method of ignition are only too well known, and to diminish these disadvantages the low-tension magneto ignition has been extensively adopted; and although in this instance a hotter and larger spark is produced within the combustion chamber, the mechanical oscillation of the tappets in the cylinder head to effect the necessary make and break within the combustion chamber in a short time causes a slight leakage, with consequent loss of compression.

In the new Lodge system, while the advantages in regard to the disruptive spark of the magneto are procured, the troubles incidental to the present high-tension system are successfully overcome. For his success the inventor relies upon what he describes as the "B" spark. The ends of the secondary winding of the coil are connected to the terminals of the inner coatings of two Leyden jars. When these inner coatings become charged, they immediately overflow and discharge across a carefully insulated and protected spark gap on top of the coil itself, this discharge being known as the "A" spark. The outside coatings of the jars are inductively charged simultaneously with the inner coats, upon whose discharge their own charge is released. These outer coats are connected to the sparking plug in the cylinder, at which gap a rush of current takes place, in its passage, breaking down the air and any other resistance, such as carbon deposit or oil. This is the "B" spark. The two sparks, however, are not two gaps in the same circuit. The "A" spark simply occurs and completes the coil circuit, while the second jar flash "B" is an additional spark, and occurs about one-millionth of a second later.

The salient feature of the Lodge system is the introduction of two capacity condensers, represented by the Leyden jars in the ignition circuit. In such a device the greatest problem is obviously the connection of the outer coatings of the jars in such a manner that they can become charged without at the same time short-circuiting the "B" spark and preventing its flash. This difficulty is overcome by the employment of a semi-conductor, consisting of damp blotting paper inclosed in a glass tube to preserve its moisture.

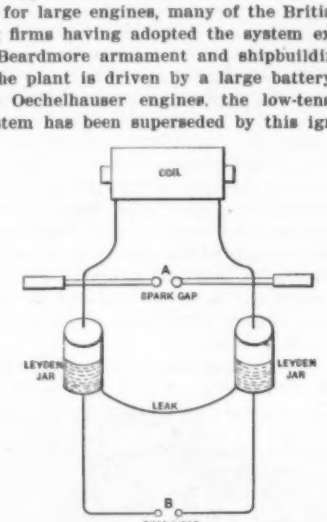
The accompanying illustration shows the general appearance of the Lodge igniter. It will be seen that up to a certain point the system is identical with the ordinary high-tension system, comprising the trembler and the secondary spark gap on the coil itself, and not as in ordinary circuits represented by the ignition plug, but in this instance for the completion of the "A" circuit. This secondary spark is not used for the ignition of the charge at all, though the latter is indirectly dependent upon it. The violent rush and



THE "B" SPARK CONNECTION ON LARGE STATIONARY ENGINES.

impulsiveness of the "B" current is such that a white-hot spark is produced, which can ignite the poorest gases and weakest mixtures. Starting difficulties are entirely avoided, while sparking can even be regularly obtained under water. The timing of the ignition can be secured with absolute precision and accuracy, while it can be readily advanced or retarded as required. Once set to the best position for all cylinders in a multi-cylinder engine, the adjustment will never alter, nor do the plugs ever require any attention, such as drying or cleaning, when once inserted in the cylinder head. If desired, more than one plug can be inserted in a cylinder, and being connected in series from one igniter, they fire the charge within precisely together from opposite points, thereby increasing the efficiency of the engine. An arrangement has been introduced for multi-cylinder engines, whereby the ignition to each cylinder is fitted with a separate switch so that the circuit can be interrupted if required without stopping the engine.

Though the system is distinctly suitable for automobile practice, being as compact and small as the ordinary apparatus, it has so far been more extensively adopted for large engines, many of the British engine-building firms having adopted the system exclusively. At the Beardmore armament and shipbuilding works, where the plant is driven by a large battery of high-powered Oechelhauser engines, the low-tension magneto system has been superseded by this igniter, and



THE THEORY OF THE LODGE HIGH-TENSION IGNITION.

it is now also adopted for ignition purposes by the builders of the Cockerill engines in England. For such engines a special type of plug has been designed. This consists of an outer shell, which fits tightly in a water-cooled liner and has an insulated central spindle. The plug is screwed into the combustion chamber, so that the ignition end within comes practically flush with the inner surface of the combustion chamber, thereby offering no surface of the plug for pre-ignition. The sparking end consists of an annular gap surrounding the spindle, so that the flash is produced all round the periphery of the latter, thereby permitting the production of a large, powerful spark. The outer end of the plug to which the coil is connected has a small spark gap, the object of which is to separate the capacity of the leads from the central spindle, so that the possibility of sparks jumping from the engine casting to the insulated spindle is completely removed. In such instances as this the ignition is run off the electric mains through resistance lamps with the battery in circuit. In this manner the battery never runs down, and never requires any attention whatever. All that has to be done is to switch on or off when starting or stopping the engine.

BRAZING CAST IRON AND OTHER METALS.

By F. N. Blake.

Brazing consists in uniting metal parts by flowing melted brass, technically termed spelter, between them. It is practically identical with soldering, except that spelter is substituted for solder, and that a much greater degree of heat is necessary. In the greater degree of heat required to melt spelter lies one of the advantages which brazed work possesses over that which is soldered, the finished work enduring more heat without breaking or weakening; but the chief advantage lies in its superior strength at all temperatures and its applicability to a large variety of uses. Cast iron is a common material which is prone to break, and which can now be brazed. The production of the necessary heat is an important part of the process of brazing, and constitutes the chief difficulty and almost the only source of expense. For small work, a plumber's hand gasoline torch can be used in what may be termed an amateur sort of way, but for common use a forge, gasoline brazer, or a jet of gas supplemented by a blast of air can be satisfactorily used. The latter constitutes the cleanest, most convenient, and most effectual brazing fire.

A bed of coke or charcoal on a forge hearth is an excellent resting place for the work during the process of brazing. A backing of firebrick or of asbestos is of considerable assistance in confining and reflecting the heat, though, of course, these do not contribute to the heating process in the way that inflammable backings do. There is considerable opportunity for the display of judgment and discretion in the arrangement of the backing; aside from the saving of time and fuel there is, on large and difficult work, all the difference between success and failure in the way the heat is applied and utilized.

Before work is assembled for brazing it should be well cleaned by file, scraper, scratch brush, or other means; rust and scale do not favor the ready flowing of the fused spelter, though it will sometimes take hold of even such unfavorable surfaces. Cast iron may be cleaned by first heating to a bright red, and, after cooling, brushing the fracture and adjacent parts with a scratch brush. After thoroughly cleaning the work and securing good bright surfaces, the parts must be fastened together in the exact position they are to occupy when the job is completed. Usually the pieces are secured by pinning, but sometimes screws, bolts, wire, clamps of various sorts, and even fire-clay can be used to hold the parts in place. Whenever practicable, the parts should be secured in such a manner that the job can be turned over during the process of brazing, without disturbing the relation of the parts to each other, thus affording a better chance to apply the flux and spelter.

Alcohol used in a common gasoline torch has been said to give a greater heat than gasoline, the reason given being that it requires less air, and consequently the flame is cooled less by it. As alcohol contains fewer heat units than gasoline, it would seem a less suitable fuel to use for this purpose, but perhaps the need of less air may explain the difference claimed for it.

A simple and good formula for cast-iron brazing is as follows:

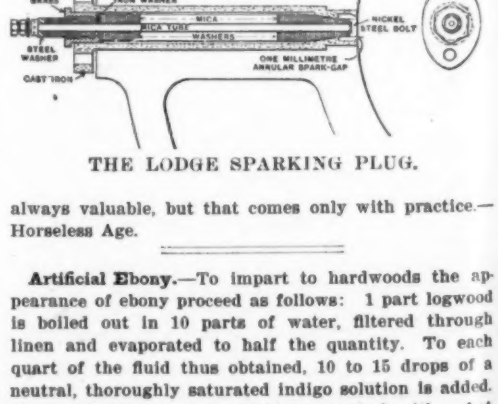
	Ounces.
Boric acid	16
Chlorate of potash, pulverized	4
Carbonate of iron	3

Mix and keep dry, as moisture or long exposure to air renders it less efficient. When used, mix with grain spelter. Heat the work to a nice brazing heat, and apply flux and spelter with an iron rod, flattened and spoon-shaped at the end.

Borax is much used for flux in brazing wrought iron and steel; it is not expensive, and one can be sure of getting a good article by buying of a reputable dealer. In any brazing the work is first brought to a bright red heat, flux is applied, and then mixed flux and spelter. Sometimes considerable "coaxing" is required in order to make the metal flow into the joints; but with the flux applied first and allowed to find its way into the cracks and openings, the spelter will follow if carefully led and rubbed with the hot iron rod. After one side of the work has been brazed, it is turned over, and the other side is treated in the same manner.

In preparing work for brazing, too close a fit may be made, for the melted brass will not find its way into the most minute recesses. One one-thousandth of an inch is about as small a space as spelter will readily flow into.

After brazing cast iron it is a good plan to let it cool slowly, sudden chilling being regarded as injurious in some cases. Whatever process is employed it is a good rule to have the work bright and clean, and to use plenty of heat; these, together with good flux and spelter, constitute the essentials. Experience is



THE LODGE SPARKING PLUG.

always valuable, but that comes only with practice.—Horseless Age.

Artificial Ebony.—To impart to hardwoods the appearance of ebony proceed as follows: 1 part logwood is boiled out in 10 parts of water, filtered through linen and evaporated to half the quantity. To each quart of the fluid thus obtained, 10 to 15 drops of a neutral, thoroughly saturated indigo solution is added. The wood parts to be colored are soaked with a hot saturated solution of alum, then painted several times with the indigo decoction. Then they are rubbed with a hot and concentrated solution of verdigris—basic acetate of copper—until the desired black shade is obtained.

LOW TEMPERATURE.*

ITS MECHANICAL PRODUCTION.

BY SYDNEY F. WALKER.

IT is always puzzling to the layman or student, when approaching the problem of mechanical production of low temperature, the art of "refrigeration," as it is called, to find that power and heat are employed. In the absorption system, heat is applied directly through the agency of steam, while in the compression system it is employed indirectly, either through steam required to operate the engine which drives the compressor, or through steam used in the generating unit which furnishes current for the motor which drives the compressor. In all cooling systems,

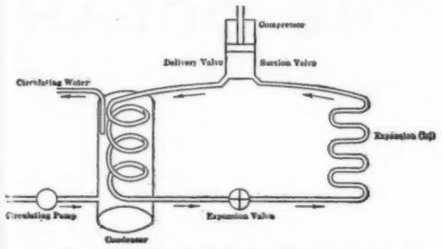


FIG. 1.—ARRANGEMENT OF A SIMPLE COMPRESSOR PLANT.

whether so-called artificial, or so-called natural, that is to say, whether the system is under the control of the engineer and cooling is produced by the aid of mechanical appliances, or whether it is brought about by the ordinary courses of nature, a fluid agent is always employed to abstract heat from the substance that is to be cooled and deliver it to some other substance whose temperature is thereby increased. Further, in the movement of the agent employed, power or energy is always expended, and this is true whether the power be delivered by appliances under the control of the engineer, or by what we understand as the "force of nature."

The most striking instance of this action in nature is afforded by the polar winds which blow over the great continents, and, except where intercepted by mountain ranges, gradually extend the snow lines farther south. These cold winds abstract heat from all things in their paths, rendering each object colder and colder, and leaving frozen rivers and masses of snow in their wakes. The winds carry the heat so abstracted to the warmer regions of the south, where it is added to the heat which has been generated by the sun's rays.

All substances have a definite capacity for absorbing heat, with a given rise of temperature. The capacity of pure water for absorbing heat at its greatest density, 39.1 deg. F., is taken as the standard for measurement. The heat unit, or, more accurately, the British thermal unit, is that quantity of heat required to raise the temperature of one pound of pure water from 39 deg. F. to 40 deg. F. Every other substance absorbs heat in a similar manner, and its capacity to do so bears a definite ratio to that of water, this ratio being called the specific heat of the substance. Thus, the specific heat of air, under the conditions in which it occurs in the atmosphere, is 0.2375, which means that a little more than four pounds of air will have its temperature raised 1 deg. F. by the delivery to it of one British thermal unit. * As air measures 13.141 cubic feet to the pound at 62 deg. F. temperature, the delivery of one British thermal unit to any body of air will raise the temperature of about 52½ cubic feet of the fluid 1 deg. F.

Heat always passes from a body at a higher temperature to one at a lower temperature, when the two are in contact, the rate at which it passes being directly as the difference of temperature between the two. Therefore it will be easily understood what a very large cooling effect the passage of the polar winds, which are at first at a very much lower temperature than the earth over which they pass, must have upon the substances with which they come in contact. Every cubic foot of air in passing will absorb a certain quantity of heat from the earth and other objects, such as the walls and roofs of houses, trees, men and other animals, in direct proportion to the difference between the temperature of the air and the temperature of the bodies over which it passes.

Another illustration of the transference of heat by the aid of fluids is afforded by steam-plant operation. The flue gases absorb heat liberated from the fuel in the furnace and transmit it through the heating surfaces of the boiler to the water. The steam in turn transmits the heat from the boiler to the engine; also, the tube walls of the condenser transmit the heat of the steam to the cooling water and thence to the body of water to which it is delivered. In each case work has to be expended upon the transmitting agent. In the case of the boiler-flue gases a definite portion of the energy liberated by the combustion of the fuel is utilized in drawing the air through the furnace and in carrying the flue gases themselves through the flues (or around the tubes in a water-tube boiler), the power so expended being definitely measurable.

A similar procedure holds in the case of refrigerating apparatus, although the apparatus itself is apparently different. All bodies, even if apparently cold, contain a certain quantity of heat, and in order that they may be cooled to a certain temperature a certain definite quantity of heat must be extracted from them. In case water is to be frozen, supposing that its initial temperature is 70 deg., which is the average temperature of water employed in America for condensing purposes, 38 heat units must be abstracted from every pound of the water, or, say, 316 heat units from every gallon, in order to reduce it to 32 deg. F., and this is done, as will be explained, by the passage of a fluid in the neighborhood of the water to be frozen.

Another property in connection with the freezing of bodies, and which is also made use of in the agents employed to extract the heat from the bodies to be frozen, or lowered in temperature, is latent heat. It is well known that while approximately one heat unit must be expended for each degree rise in temperature between 32 deg. and the boiling point of water, when the boiling point is reached and the water is converted into steam, 966 heat units are absorbed by the same pound of water in order to convert it into steam of the same temperature as the water from which the steam is formed. These 966 heat units constitute what is known as the latent, or invisible, heat of steam. Similarly, when water is converted into ice, the temperature of the water is lowered by 1 deg. for approximately each heat unit, down to the temperature of the freezing point, when the forming ice and the water of which it is being formed are of the same temperature, but in order to freeze it 142.4 heat units have to be extracted from each pound.

In the practical manufacture of ice, and also in nature's great ice factory, the process is always carried below the freezing point, the temperature of the ice being considerably lowered by the further abstraction of heat, to insure solidarity or stability. The specific heat of ice is only 0.504, or approximately one-half that of water, and therefore only one-half of one heat unit has to be abstracted from each pound of ice to lower its temperature 1 deg. F. The temperature of mechanically produced ice after formation is lowered to about 15 deg. F., while naturally produced ice often reaches a much lower temperature.

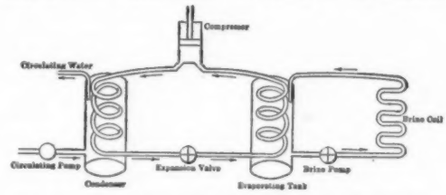


FIG. 2.—ARRANGEMENT OF A COMPRESSOR PLANT WITH BRINE CIRCULATION.

condition, inside of a coil of pipes provided for the purpose. The gaseous carbonic acid, ammonia, or sulphuric acid is then caused to pass to the compressor, thence to the condenser, where it is reconverted into liquid, and again sent through the evaporating coils, as they are called, in which it again takes the gaseous form, and so on almost indefinitely. Power, therefore, is required at every step of the process. When the liquid carbonic acid, or whatever is used, is admitted to the evaporating coils, it immediately expands in the space provided for it, and in so doing abstracts a proportionate amount of heat from the air of the cold chamber, or from the water, brine or other substance with which the pipe through which the gas is passing is in contact. The passage of the heat, from the substance to be cooled, to the liquid in the evaporating coils confers upon the latter the power of expanding, contributing largely to the process. Then, later, when the gas passes on to be reconverted to a liquid, an equivalent amount of work has to be done upon it.

The work done upon the gas in the compressor appears in the form of heat in the gas, raising its temperature from that it had assumed in the evaporating coils to a considerably higher degree, the actual temperature depending upon the conditions present. This work is measured by the heat liberated in the gas, and the power that must be delivered to the compressor piston is measured by the work done upon the gas plus the work demanded by the compressor piston itself, necessary to overcome friction.

When the gas passes on to the condenser, it is converted to a liquid by exactly the same process by

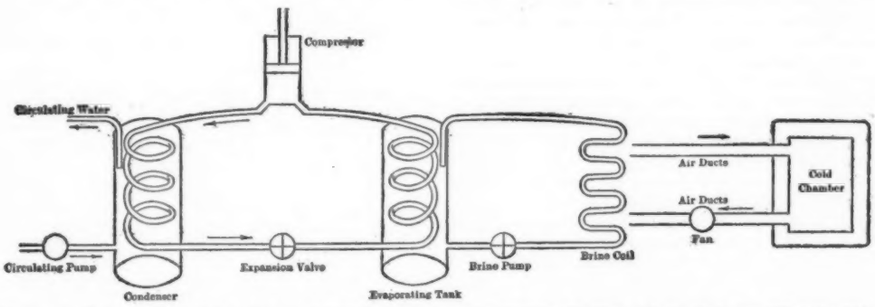


FIG. 3.—ARRANGEMENT OF A COMPRESSOR PLANT WITH BRINE AND AIR CIRCULATION.

Ice at 32 deg. F., or even a little below that, is liable to become converted into water, through friction, or slightly increased temperature of the surrounding atmosphere, or other cause.

Carbonic acid, ammonia, sulphuric acid, ether, and a few other substances of gaseous origin are employed in the mechanical production of low temperature, because they are so readily converted from the gaseous to the liquid state and *vice versa*. Any one of these substances, after it has been liquefied, can only be reformed into a gas if two conditions are present: if it has space in which to expand to the gaseous state, and if it can obtain the heat necessary to enable it to expand. One pound of carbonic acid at zero F. requires the presence of 123.2 heat units to expand it to a gas; at the same temperature, one pound of liquid ammonia requires 555.5 heat units to expand it to the gaseous state, and to transform one pound of sulphurous acid requires 171.2 heat units. Ether and other substances referred to are not often used for mechanical refrigeration, except in hot climates.

In refrigerating apparatus, one of the three substances mentioned—carbonic acid, ammonia, sulphuric acid—is employed to extract heat either from the air of a cold chamber and its contents, or from the water from which ice is to be formed, by allowing the agent employed to expand from the liquid to the gaseous which steam is converted to water in a surface steam condenser, i. e., by the passage of water over the pipe through which the gas flows. The latent heat of the gas has to be abstracted from it, and in addition the heat that was delivered to it in the compressor. For this purpose, circulating water has to be pumped through the condenser, just as in a steam condenser, and power is required to drive it, the power varying with the quantity of water needed, and the conditions under which the condenser works. More power is required with some types of condenser than with others, owing to the greater friction, although it is claimed for those in which the friction is greater that

* Abstracted from Power.

the efficiency is higher. The quantity of water required depends inversely upon its initial temperature.

A small quantity of power is necessary, also, to enable the compressor to perform its function as a pump to draw the gaseous refrigerant from the evaporating coils through the suction valves into the compressor cylinder. Often, too, power is required for driving brine through the evaporating tank and the cooling pipes.

For many purposes it has been found advisable not to locate the evaporating coils in the room to be cooled, or in the tank from which ice is to be made, because, as in the case of ammonia, the escape of a small quantity of the gas through a leaky joint will have a serious effect upon the stored product and the forming ice. Frequently, therefore, a second fluid (in this case a liquid) is used to transmit the heat from the substance to be cooled to the evaporating tank. The liquid so employed is technically called "brine." It consists of a solution, usually of calcium chloride. It is necessary that this liquid should have a lower freezing point than the water which is to be frozen by its aid, and this is easily arranged by dissolving a certain quantity of the salt in the water to be used. The brine so formed is kept continually moving through pipes leading to the ice tank, or cold store, thence through pipes in the tanks, or stores, and back to the evaporating tank, power being required to drive the pump which produces this circulation, the power again depending upon the quantity of the brine to be moved, its velocity, and so on.

In the most recent cold-storage plant, also, the air is cooled either by passing over pipes in which cold brine is circulating, over pipes in which a refrigerant is in course of expansion, or, more frequently, by passing through a battery of plates over which cooled brine is circulating, the brine taking up the moisture that has been brought by the air from the cold store, the air being circulated, by means of fan blowers, through ducts leading from the cold store to the cooling plant and back to the store again. Power is required for driving the fans.

The power required for the different apparatus mentioned necessarily varies with the differing conditions. As a rule more power is taken by each part of the apparatus if the design is bad, that is, if undue friction is allowed to be set up at any part, and if the velocity of any of the fluids employed is required to be increased to a considerable extent. The power required to move any fluid, under any given conditions, varies directly as the square of the velocity of the fluid, and wherever the fluid is throttled the power required to move it increases very rapidly. There are laws governing the quantity of power required for each of the parts of the apparatus, and for each case that arises.

The accompanying sketches, Figs. 1, 2 and 3, show diagrammatically the usual arrangement of a simple compressor plant, of a compressor plant with brine circulation, and of a compressor plant with brine and air circulation, respectively.

RADIUM IN ROCKS AND IN THE OCEAN.*

A NEW GEOLOGICAL THEORY.

BY PROF. JOHN JOLY, M.A., D.SC., F.R.S.

THE fact first established by Strutt that the radium distributed through the rock materials of the earth's surface greatly exceeds any permissible estimate of its internal radio-activity has not as yet received any explanation. It might indeed be truly said that the concentration of the heaviest element known to us (uranium) at the surface of the earth is just what we should not have expected. Yet a simple enough explanation may be at hand in the heat-producing capacity of that substance. If it was originally scattered through the earth-stuff, not in a uniform distribution, but to some extent concentrated fortuitously in a manner depending on the origin of terrestrial ingredients, then these radio-active nuclei heating and expanding beyond the capacity of surrounding materials would rise to the surface of a world in which convective actions were still possible and, very conceivably, even after such conditions had ceased to be general; and in this way the surface materials would become richer than the interior. For instance, the extruded mass of the Deccan basalt would fill a sphere 36 miles in radius. Imagine such a sphere located originally somewhere deep beneath the surface of the earth surrounded by materials of like density. The ultimate excess of temperature, due to its uranium, attained at the central parts would amount to about 1,000 deg. C., or such lesser temperature as convective effects within the mass would permit. This might take some thirty million years to come about, but before so great an excess of temperature was reached the force of buoyancy developed in virtue of its thermal expansion must inevitably bring the entire mass to the surface. This reasoning would, at any rate, apply to material situated at a considerable distance inward, and may possibly be connected with vulcanicity and other crustal disturbances observed at the surface. The other view, that the addition of uranium to the earth was mainly an event subsequent to its formation in bulk, so that radio-active substances were added from without and, possibly, from a solar or cosmic source, has not the same *a priori* probability in its favor.

I will give briefly an account of my experiments on the amounts of radium distributed in surface materials. Here, indeed, direct knowledge is attainable; but this knowledge takes us but a very few miles inward toward the center of the earth.

The Igneous Rocks.—The basalt of the Deccan, to which I have referred, known to cover some 200,000 square miles to a depth of from 4,000 to 6,000 feet or more, appears to be radio-active throughout. A fine series of tunnel and surface specimens sent to me by the director of the Indian Geological Survey has enabled me to examine the radio-activity at various points. It is remarkable that the mean result does not depart much from that afforded by a long series of experiments on North of Ireland basalt and on the basalt of Greenland.

Again, the granites and syenites—and those of Mourne, Aberdeen, Leinster, Plauen, Finsteraarhorn have been examined—while variable, yet approximate to the same mean result.

In the Simplon and St. Gothard tunnels igneous rocks have been penetrated at considerable depth beneath the surface. The greatest true depth is attained, I think, in the central St. Gothard massif. It is remarkable, and may be significant, that in these rocks I have reached the lowest radio-activities I have met—down to almost one-billionth of a gramme of radium per gramme; although the general mean of the St. Gothard igneous rocks, owing to the high radio-activity of the Finsteraar granite at the north end of the tunnel, is not exceptionally low. Radio-active minerals seem common in the Simplon rocks, involving considerable variations in successive experiments. Some of the highest results are omitted in the mean given below, but as it is difficult to know what to allow for purely sporadic radium the mean is not very certain. In the case of a specially high result I asked Prof. Emil Werner to determine the uranium; my result was confirmed. My list of mean results on igneous rocks up to the present is the following:

Basalts (14)	*5.0	Lewisian Gneiss (3)	5.7
Granites (6)	4.1	Simplon (32)	7.6
Syenites (1)	6.8	St. Gothard (32)	5.1

The general mean is 6.1.

From the igneous rocks have originated the sediments after a toll of dissolved substances has been paid to the ocean. It does not of course follow necessarily that the percentage of radium, or more correctly of uranium, in the sedimentary rocks should be less than in the igneous. The residual materials might keep the original percentage of the parent rock, or even improve upon it. There are reasons for believing, however, that there would be a diminution.

Those sedimentary rocks which have been derived from materials formerly in solution offer a different problem. In their case there is little or none of the original materials carried into the secondary rock, and the radio-activity will depend mainly upon how far uranium is precipitated or abstracted with the rock-making substances. In other words, upon how far the waters of the ocean will restore to the rocks what it has borrowed from them.

This brings me to consider the condition of the ocean as preparatory to quoting experiments on the sediments.

The Ocean and Its Sediments.—The waters of the ocean, covering five-sevenths of the earth's surface to a mean depth of 3.8 kilometers, represent the most abundant surface material open to our investigation. As the mean of a very large number of experiments upon twenty-two different samples of sea-water from various widely separated parts of the ocean, I obtain a mean of 0.016×10^{-12} gramme per cubic centimeter. There is considerable variability. Taking the mass of the ocean as 1.458×10^{18} tonnes, there must be about 20×10^9 grammes (20,000 tons) of radium in its waters.

The experiments which I have been able to make on deep-sea deposits, thanks mainly to the kind co-operation of Sir John Murray, apply to ten different materials of typical character.

The results are so consistent as to lead me to believe that although so few in number they cannot be far wrong in their general teaching.

The means are:

	Radium.	Extension: Millions of Square Miles.
Globigerina Ooze	7.2	49.5
Radiolarian Ooze	36.7	2.5
Red Clay	33.3	51.5

Diatom oozes have not yet been examined.

It is apparent from these results that the more slowly collecting sediments are those of highest radio-activity, as if the organic materials raining downward from the surface of the ocean carried everywhere to the depths uranium and radium abstracted from the waters, but in those regions where the conditions were inimical to the preservation of the associated calcareous tests there was the less dilution of the radio-active substances accumulating beneath. The next table shows that radio-activity and the percentage of calcareous matter in these deposits stand in an inverse relation:

		Calcium Carbonate, per cent.	Radium
Globigerina Ooze, "Challenger"	338	92.24	6.7
Globigerina Ooze, "Challenger"	296	64.34	7.4
Red Clay, "Challenger"	5	12.00	15.4
Red Clay, "Challenger"	276	28.28	52.6
Radiolarian Ooze, "Challenger"	272	10.19	22.8
Radiolarian Ooze, "Challenger"	274	3.89	50.3

The percentages of calcium carbonate are from the report of the "Challenger" expedition. The red clay in the table, which reads as an apparent exception, is probably a case of recent change in the character of the deposit, for the evidence of manganese nodules and sharks' teeth brought up with this clay is conclusive as to the slow rate of its collection. Readers of Sir John Murray's and Prof. Renard's report will remember many cases where recent change in the character of a deposit is to be inferred.

A point of much importance in connection with our views on oceanic radio-activity is that of the presence in the waters and in the deposits of the parent radio-active substance, uranium. The evidence that the full equivalent amount of uranium is present is, I believe, conclusive.

In the first place, to so vast a reservoir as the ocean the rivers cannot be supposed to supply the radium sufficiently fast to make good the decay. In a very few thousand years, in the absence of uranium, the rivers must necessarily renew almost the entire amount of radium present. I have made examination of the water of one great river only—the Nile. The quantity of radium detected was 0.0042×10^{-12} per cubic centimeter. That is less than the oceanic amount. In short, it is evident that the uranium must accumulate year by year in the oceanic reservoir, like other substances brought in by the rivers, and that the present state of the waters is the result of such actions prolonged over geological time.

While this reasoning is conclusive as regards the waters of the ocean, it does not assure us that the sediments accumulating in their depths are throughout as radio-active as their surface parts would indicate. There might be a precipitation of radium unattended by uranium, in which case their deeper parts would not be radio-active.

Against this possibility there is the evidence of such true deep-sea deposits as were formed in past times and to-day still preserve their radio-activity. For instance, the chalk, which, considering that it was undoubtedly a very rapidly formed deposit, exhibits a radio-activity quite comparable with that of the Globigerina oozes, deposits which it most nearly resembles. In

* Abstracted from a paper read before the British Association for the Advancement of Science.

* This number is to be multiplied by 10^{-12}, and represents billionths of a gramme of radium per gramme of material investigated. Throughout the rest of my address this understanding holds, unless where a different meaning is specified. The numbers in parentheses signify the number of different specimens investigated.

this deposit, clearly, the uranium must have collected along with the calcareous materials. We can with security argue that the similar oozes collected to-day must likewise contain uranium. In the case of the red clays we have the direct determination of the uranium which Prof. Emil Werner was so good as to make at my request. Considering the difficulties attending its separation, the result must be taken as supporting the view that here, too, the radium is renewed from the uranium. Regarding the efforts of other observers to detect uranium in such deposits, it is noteworthy that without the guidance of the radium, enabling specially rich materials to be selected for analysis, the success of the investigation must have been doubtful. The material used was a red clay with the relatively large quantity of 54.4 billionths of a gramme per gramme. In a few grammes of this Werner obtained up to seven-twelfths of the totol theoretic amount, and of course the separation of the uranium is not likely to have been complete.

It might be thought a hopeless task to offer any estimate of the total bulk of the sub-oceanic deposits, and from this to arrive at some idea of the quantity of radium therein contained. Nevertheless, such an estimate is not only possible, but is based on deductions which possess considerable security. As a major limit I believe the estimate of the total mass of deposit is unassailable, and such deductions as might be applied will still leave it an approximation to the truth.

The elements of the problem are simple enough; we know that the sedimentary rocks have been derived from the igneous, some 30 per cent of the latter entering into solution in the process of conversion. Some of the soluble constituents, owing to their great solubility, have remained in solution since they entered the ocean.* These are the salts of sodium. An estimate of the amount of these salts in the ocean gives us a clue to the total amount of rock substance which has contributed to oceanic salts and oceanic deposits since the inception of the oceans. Some years ago I deduced on this basis that the igneous rocks which are parent to the sodium in the sea must have amounted to about 91×10^{20} tons.† This figure in no way involves the rate of supply by the rivers, or our estimate of geological time. It only involves the quantity of sodium now in the ocean—a fairly well-known factor—and the loss of this element, which occurs when average igneous rocks are degraded into sedimentary rocks—a factor also fairly well known. Mr. F. W. Clark, to whom geological science is indebted for so much exact investigation, has recently repeated this calculation, using data deduced anew by himself, and arrives at the result that the bulk of the parent igneous rock was 84.3×10^8 cubic miles.‡ On a specific gravity of 2.6 my estimate in tons gives nearly the same result: 84×10^8 cubic miles.

Now about one-third part of this parent rock goes into solution when breaking up into a detrital sediment. The limestones upon the land are part of what was once so brought into solution. Having made deduction of these former marine deposits (and I here avail myself of Van Hise's and Clark's estimates of the total amount of the sedimentaries and the fraction of these which are calcareous)§, and, allowing for the quantity remaining in solution in the ocean, the result leaves us with the approximation of twenty million cubic miles of matter once in solution, and now for the greater part existing as precipitated or abstracted deposits at the bottom of the ocean. We are to distribute this quantity over its floor. If the rate of collection had been uniform in every part of the ocean throughout geological time, a depth of about one-seventh of a mile (240 meters) of deposit would cover the ocean bed.

While, I believe, we can place considerable reliance on this approximation, we are less sure when we attempt an estimate of its mean radio-activity. If we assume for it an average radio-activity similar to that of Globigerina Ooze, we find that the quantity of radium involved must be considerably more than a million tons. Apart from the value which such estimates possess as presenting us with a perspective view of the great phenomena we are dealing with, it will now be seen that it supports the finding of the experiments on sedimentary rocks, and leads us to anticipate a real difference in the radio-activity of the two classes of material.

The Sedimentary Rocks.—The radium content of those of detrital character is indicated in the following sandstones, slates, and shales:

Shales, sandstones, grits (10)	4.4
Slates (Cambrian, Devonian)	4.7
Mud from Amazon	3.2

Some of the above are from deep borings in carboniferous rocks (the Balfour and Burnlip bores),‖ and from their nature, where not actually of fresh-water origin, can owe little to oceanic radio-activity. Many of the following belong to the class of precipitates, and therefore owe their uranium wholly or in part to oceanic source:

Marsupites chalk	4.2
Green sandstone	4.9
Green sand (dredged)	4.5
Limestones and dolomites [Trenton, Carboniferous, Zechstein, Lias, Solenhofen (7)]	4.1
Keuper gypsum	6.9
Coral rock, Funafuti bore (4)*	1.7
Trias-Jura sediments, Simplon: 17 rocks of various characters	6.9
Mesozoic sediments, St. Gothard: 19 rocks of various characters	4.2

The general mean on sixty-two rocks is 4.7.

Making some allowance for uncertainties in dealing with the Simplon rocks, I think the experiments may be taken as pointing to the result:

Igneous rocks from 5 to 6.

Sedimentary rocks from 4 to 5.

If our estimate of oceanic radium be applied to the account of the sedimentary rocks in a manner which will be understood from what I have already endeavored to convey, there will be found to exist a fair degree of harmony between the great quantities which we have found to be in the sediments of the ocean and the impoverishment of the sediments which the experiments appear to indicate.

In all these results fresh and unweathered material has been used. The sand of the Arabian desert gave me but 0.4. Similarly low results have been found by others for soils and such materials. These are not to be included when we seek the radio-activity of the rocks.

As regards generally my experiments on the radium-content of the rocks, I cannot say with confidence that there is anything to indicate a definite falling off in radio-activity in the more deeply-seated materials I have dealt with. The central St. Gothard and certain parts of the Deccan have given results in favor of such a decrease. On the other hand, as will be seen later, the granite at the north end of the St. Gothard and the primitive gneiss of the Simplon show no diminution. According to the view I have put forward above as to the origin of the surface richness in radium it is, I think, to be expected that, while the richest materials would probably rise most nearly to the surface, there might be considerable variability in the radio-activity of the deeper parts of the upper crust.

* Trans. Royal Dublin Soc., vol. vii., ser. ii., pages 23 *et seq.*

† Ibid., page 46.

‡ "The Data of Geochemistry," by F. W. Clark, page 29.

§ Ibid., page 31.

‖ For these rocks, and for much other valuable material, I have to thank Mr. D. Tate, of the Scottish Geological Survey.

LIQUID CRYSTALS AND SOLID SOLUTIONS.

By PROF. O. N. WITT.

RECENT progress in science has confronted us with several things that are exceedingly difficult to comprehend. One of these is the solid solution, a conception which has enabled me to elucidate the nature of glass, the most wonderful of manufactured substances, and to explain the remarkable processes which take place in the dyeing of textiles. I wish now to report some further advances in this field for the understanding of which it is necessary to consider another phenomenon equally difficult to comprehend—the liquid crystals discovered and investigated by Prof. Otto Lehmann.

It is very difficult to form a conception of liquid crystals, for the word crystals at once suggests sharp edges, solidity and invariability of form, and liquid crystals possess none of these characters. But crystals are characterized by internal as well as by external peculiarities. Even the early crystallographers very properly attached great importance to the optical properties of crystals, which result from the peculiar arrangement and intimate mutual dependence of their molecules. The phenomena of double refraction, polarization, polychromism, etc., are exhibited only by crystals and may be regarded as visible expressions of the internal stresses resulting from the close approximation and regular arrangement of their molecules.

Now, Lehmann has discovered that many substances, on cooling after fusion, do not pass directly from the ordinary liquid to the crystalline solid condition, but go through an intermediate stage, in which they retain the external characters of liquids, which are revealed in the power to form drops and to assume the form of the containing vessel, and at the same time exhibit the internal optical characters of crystals. Lehmann has given the name of liquid crystals to these crystalline drops, and has collected a vast mass of experimental results in his study of this remarkable phenomenon. Some substances can be kept in this liquid-crystalline condition for a long time, and the processes of growth, coalescence, and mutual absorption are even more curious and interesting in liquid crystals than in ordinary solid crystals.

The more the process of crystallization is studied the more evident it becomes that the transition from the liquid to the solid state is not so simple as it appears at first glance. Liquid crystals represent one stage of the process, and another stage is represented by the "labile" crystal forms, which have been known longer, but were first thoroughly investigated by Lehmann.

It is not my purpose to give an exhaustive description of Lehmann's beautiful researches, which have been continued through many years. I wish merely to draw some practical conclusions from his investigations.

In former articles I have shown that ordinary glass is a solid liquid. It is a true liquid when it lies in the molten condition in the furnace, especially during the process of refining, when it is raised to a very high temperature and is thin and mobile. As it cools it gradually becomes thicker and more viscous until its molecules lose their mobility to such a degree that it appears like a solid body. If the process of cooling had been conducted with sufficient slowness the glass would have crystallized, and this occasionally occurs in practice if the pasty condition is maintained for a very long period. But glass that has crystallized in this way has so little of the characteristic properties of ordinary glass that it was designated by the old glass-makers by the epithet "unglazed." I have repeatedly pointed out that glass in the ideal condition of a solid liquid is equally unlike ordinary glass. Ideal solid liquids are represented by Prince Rupert's drops and Leyden flasks, which are very liable to explosive disruption. Glass is freed from this explosive character by "tempering," that is, by maintaining a high temperature long enough to start the process of solidification, but not long enough to "unglaze" the glass. I have proved that in this process of tempering true crystals are formed, which are at first invisible because their index of refraction is the same as that of the liquid glass which surrounds them.

I have often wondered how, in the process of tempering, the still uncrystallized glass so completely loses the explosive fragility which characterizes Prince Rupert's drops. In all probability this result is due to a transformation into liquid crystals, which are formed most readily in substances which are viscous in the molten condition. In this crystalline state the molecules have formed close connections which prevent the explosion of the mass on the slightest rupture of the tense outer surface.

Another interesting application of Lehmann's discovery of the nature of liquid crystals may be made to a new industry, the manufacture of artificial gems. Artificial rubies cannot be produced simply by cooling fused silica, which has been colored red with chromium. There is now no difficulty in fusing silica in large quantities, but the crystals which the silica forms on cooling are opaque and quite unlike rubies both in form and in optical properties. Verneuil first succeeded in making artificial rubies by blowing finely-divided silica through an oxyhydrogen blowpipe into the oxyhydrogen flame, inclosed in a little oven, where a drop of fused silica formed on the end of a rod and gradually increased in size and hardened until it fell off as a transparent red bead. The method by which the German Gem Company (Deutsche Edelsteingesellschaft) produces artificial rubies on a large scale has not been made public, but it is probably similar to Verneuil's method, as the uncut rubies are spherical beads. These beads possess precisely the same optical properties that are characteristic of natural rubies, which have probably been formed by a similar process.

Hence the uncut artificial ruby is a crystal in internal structure but a liquid in external form, for only liquids can assume the form of drops. At the high temperature at which the bead was formed its molecules possessed the mobility characteristic of liquids, but this mobility, as in the case of glass, was lost in cooling. The result is a double paradox, a solid liquid crystal. The liquid character is shown, not only by the form, but also by the strong surface tension. This tension is so great that the bead would fly into pieces if an attempt were made to polish or chip it directly into a faceted gem of maximum size. It is, therefore, first split into halves, which can be cut with safety, as the surface tension extends only over their convex faces.

The new artificial rubies are often called "reconstructed" rubies and thus improperly likened to the imitation rubies which were invented by a certain German clergyman some forty years ago. These imitations were exactly like natural rubies superficially, but were not identical with them throughout, as the new artificial rubies are. They were made by heating in the oxyhydrogen flame the dust and chips resulting from the cutting of genuine rubies. But while the fragments were welded together into a homogeneous mass, they were not transformed into a single crystal and optical examination showed an aggregation of many fine crystals. This result is intelligible in the

* For these I have to thank the trustees of the British Museum and Mr. A. S. Woodward, F.R.S.

light of our present knowledge of liquid crystals. The fragments were heated until they became liquid crystals, but not to the point of true fusion. The liquid crystals adhered to each other but remained distinct. If the heating had been prolonged sufficiently the larger fragments would have absorbed the smaller ones and finally coalesced to form a single crystal. If, on the other hand, the temperature had been raised, true fusion would have taken place, and cooling would have produced not a ruby, but common crystallized red corundum.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Prometheus.

CASTING PIPES IN PERMANENT MOLDS.*

A NEW PROCESS OF MANUFACTURE.

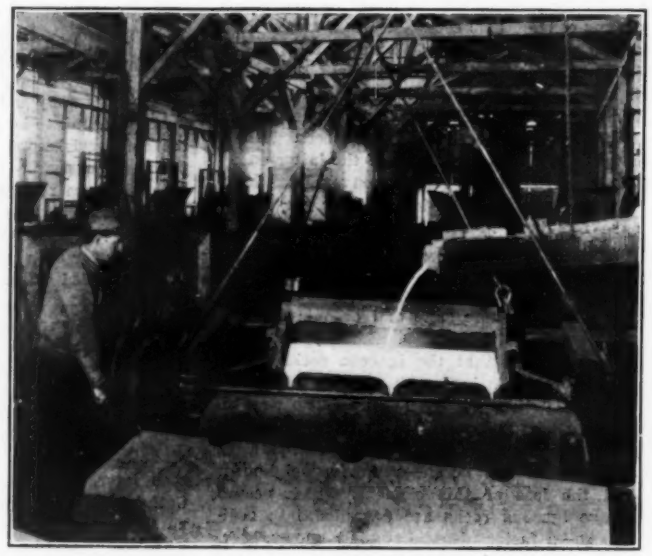
BY EDGAR A. CUSTER.

THE purpose of this paper is to describe a method and apparatus using permanent molds, that the hottest iron attainable from the cupola does not destroy, producing cast-iron pipe in which the supposed evils of unequal heating and cooling not only do not appear, but do not exist.

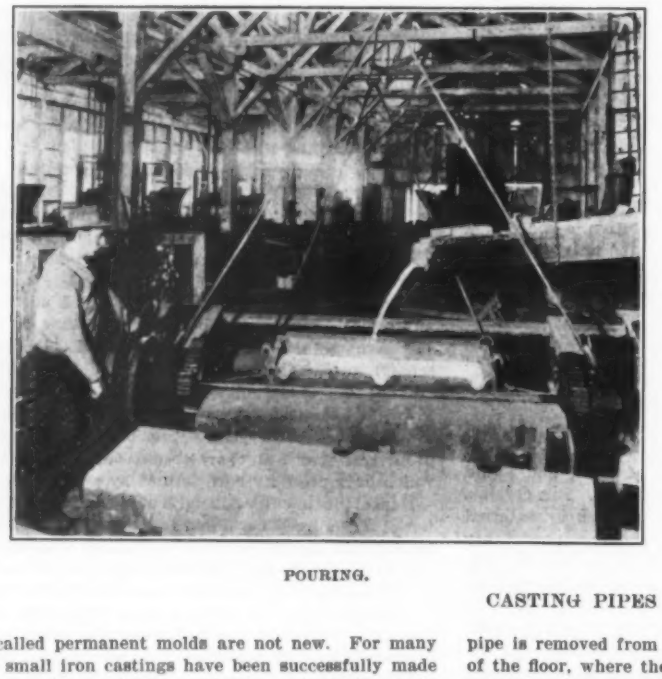
THE METHOD RELATES ONLY TO SOIL, WATER, OR GAS PIPE.

In making soil pipe, iron flasks, a cope and drag are rammed with sand over a metal pattern; a green sand core is introduced, and the cope and drag are clamped together. The pipe is then poured, with the pipe in a horizontal position, and after cooling, the pipe is removed from the flask and carried to the end of the floor, where the cores are removed. Then it is carried to the cleaning room, where the sand is rattled off, and the gates and fins are removed. After inspection it is ready for shipment. Altogether the pipe has to be handled ten times. In this process the loss is very great. Much depends upon the condition of the sand. It may be too wet or too dry; the molder may ram carelessly, or may pour his iron negligently, so that the foundry loss often reaches 12 per cent to 15 per cent. In summer weather the output is decreased 25 per cent to 40 per cent, due to the inability of human beings to stand the exacting and exhausting labor. Only one heat a day can be poured in any season. In fact, with very few improvements, and these relating mainly to cores, we are making soil pipe in precisely the same manner and with just as much labor per pipe as was the practice fifty years ago. It is true that the workman of to-day makes more pipe in one day than his grandfather did, but this is due more to the fact that the present-day workman is working by piece and has become infinitely more skilled in saving the seconds of time for each particular operation and avoiding the useless motions in performing them. Any process that would save the use of sand for the mold and would produce pipe that could be easily cut would of necessity be very desirable. If in addition it would obviate cleaning and chipping and could be run continuously night and day, it would very nearly meet the conditions of an ideal business. When experiments to discover and perfect such a process were undertaken, the first mold made was closely modeled from the flasks in use in the sand process. In fact, all the traditions of foundry practice were closely followed. The apparent danger of pouring molten iron into iron molds incasing a damp sand core was considered to be serious, and the problem of disposing of the resultant gases it was thought would prove to be a great one. Again, the pipes were less than one-fourth of an inch thick and it was necessary to pour the iron very quickly. So far as was known, no one had successfully poured a complete pipe in an iron mold, and such attempts as had been made had destroyed the mold very quickly. A mold six feet long would be permanently warped in a short time, hence it is not surprising that the experiments were approached with considerable trepidation. The first mold made consisted of a cope and drag, each six feet long, ten inches wide, and six inches thick, with gates cut into the drag, as illus-

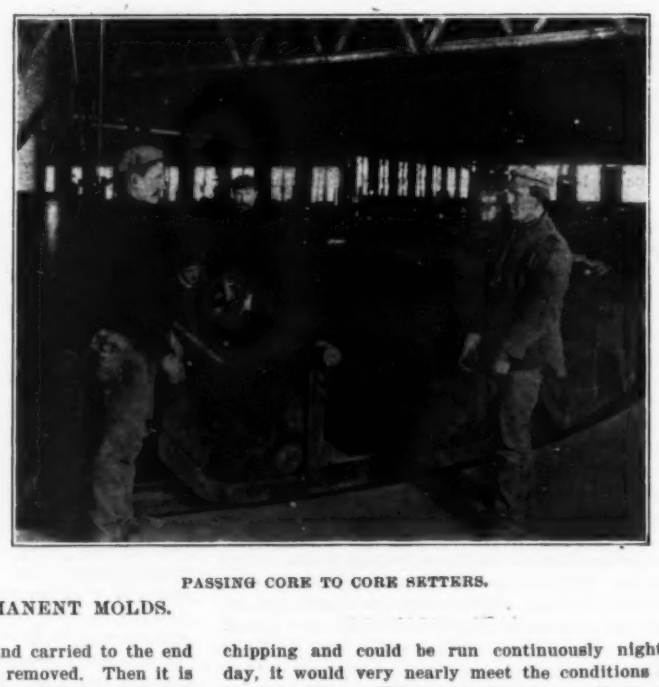
FINISHED CORE.



ORIGINAL POURING DEVICE, LADLE IN LOWER POSITION.



POURING.



PASSING CORE TO CORE SETTERS.

CASTING PIPES IN PERMANENT MOLDS.

So-called permanent molds are not new. For many years small iron castings have been successfully made in iron molds, and this without great detriment to either the casting or the mold. These castings, however, were invariably very small and were chilled to extreme hardness. Fortunately it was not necessary to machine them. This limited the use of such molds very materially. Some years ago the Latrobe Steel Company cast car couplers in iron molds. Recently an article was published describing a successful method of making brake shoes in this manner. These shoes weighed about twenty pounds each and with the exception of steel ignots and car couplers were the heaviest castings made in iron molds. So far as can be learned, this is about the extent of the art. It has been the dream of every foundryman whose trade requires a large number of duplicate castings, to make these castings in molds that would not only survive the process, but would also produce castings that would be marketable and be easily machined.

* Journal of the Franklin Institute.

trated. This mold was cast of very soft iron and the pipe shape bored out. The pouring holes were tapered so that when the cope was removed the iron in them could be easily knocked out. In order to avoid as far as possible all traces of moisture the mold was heated to 500 deg. F. An ordinary green sand core was inserted, and four men poured molten iron into the gates. These men wore goggles and were swathed completely in wet cloths. It was not then known what would happen. As it turned out, nothing happened—not even a semblance of pipe. The gates were too small. A short session with a hammer and chisel made them larger, and on the second attempt a complete pipe was poured. It was not a remarkable pipe except for its defects. It was streaked with cold shot. The top was filled with flat spots where the gases had been trapped, and it was as hard as flint. After an infinite number of experiments the mold now in use was evolved. After fifty or sixty pipes had been cast in this mold, it became badly cracked around the gates, and, as the process of casting was continued, these cracks extended into the barrel of the mold. It was sought to obviate this by casting into a new mold very thin strips of mica, extending throughout the length of the mold and placed radially at intervals around the barrel or mold cavity. The cracks in this mold would start as before but would stop when the mica was reached. A good illustration of this effect is shown by the fact that a small hole drilled at the extremity of a crack in a sheet of plate glass immediately stops the further extension of the fracture. In time the whole face of the mold would show a collection of fine cracks, most of which could be seen only with a magnifying glass. They were rarely ever more than 1/16 inch deep. After probably 200 pipes had been cast the surface of the mold in contact with the molten iron resembled an extremely hard graphite. It was dull black in color, but did not scale or shell off. In order thoroughly to test the mold, the ends were stopped up with sand and the entire barrel, without a core, was filled with molten iron. This was done thirty or forty times without any appreciable deterioration of the outline. The only care exercised was to take the casting out before heavy shrinkage set in. In order still further to test it, the mold was heated to a temperature of about 1,100 deg. F. in a furnace, but it was found impossible to produce pipe under these conditions. The molten iron danced in the mold like water on a hot griddle, and the resultant pipe was a collection of closely-knit globules. It was found that the safe casting-heat of the mold was about 700 deg. F., but that in a practical working 250 deg. F. to 400 deg. F. was the highest heat the molds reached. The actual time in which the metal set was carefully noted, and the behavior of the cast metal at extremely high temperatures was observed. Irons high and low in silicon, sulphur, carbon or phosphorus were cast a great many times, and copious notes were taken in each case. A small chemical laboratory was established for this work. In all, over 4,600 pipes were cast in 4-inch pipe mold, 2,700 in a 2-inch mold, and over 1,100 in a 6-inch mold. Not one of these molds shows any signs of deterioration over and above the first cracking as described before; in fact, they are in a far better condition than at the start. Each one has been purposely abused and submitted to treatment that never occurs in practice. A straight edge to-day laid in the barrel shows the surface to be perfectly straight, and the 4,600th pipe shows the original marks of the boring-out tool.

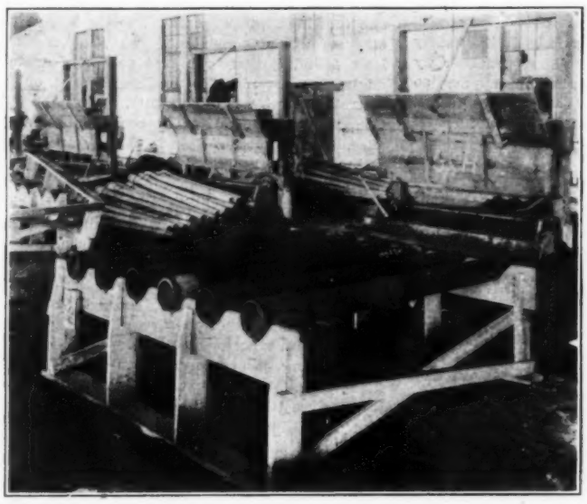
It was found that an iron running from 2.00 to 2.25 silicon and high in carbon produced the greatest number of perfect pipes, and when cast iron of this silicon had a comparatively low sulphur content, the result was still better. Further experiments showed that powdered ferro-manganese, when added to the molten iron, immediately combined with the sulphur as a manganese sulphide, and rose to the top of the liquid mass as a slag. An excess of manganese, however, produced a hardening effect, as it formed with the carbon a carbide which in itself is an extremely hard substance.

These features made it possible to use a high sulphur cast iron, provided its other contents approximated the figures given above.

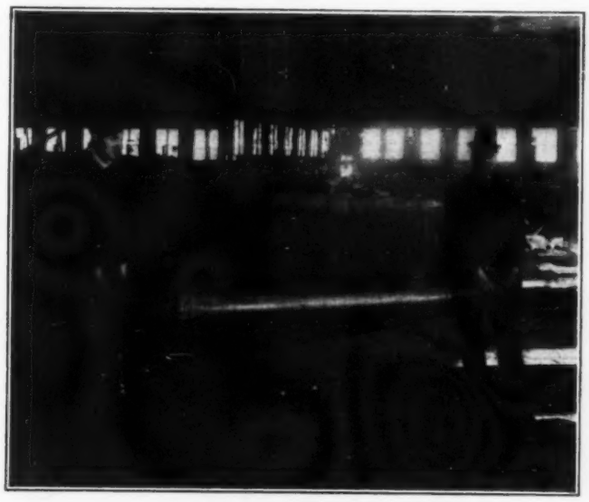
It was then noted that pipes which remained in the mold until a dull red heat was reached were very hard, and in most cases were too hard to cut. When they were taken out at a bright yellow heat and allowed to cool normally, they were perfect in texture. It was further noticed that when the dull red pipes were piled with the very hot bright yellow pipes, an annealing process was set up that brought the iron in the dull red pipes into a workable condition. This feature of temperature was the subject of a long and patient investigation, and the causes leading thereto may be now briefly stated.

Pure iron possesses no fluidity, or the property of low shrinkage, nor does it possess varying degrees of hardness. It is obvious then that the characteristics of cast iron, which possesses these qualities in a high degree, are due to the presence of impurities, such as carbon, silicon, phosphorus, etc. Carbon is the main element and exists in cast iron as combined and free carbon. The amount of free carbon, which is the principal softener of cast iron, depends principally upon the rate of cooling. If molten iron high in carbon be cooled slowly, the free carbon separates out in the form of graphitic carbon. If this molten iron be suddenly cooled, the carbon is caught before it has time to separate and is held in an atomic condition by the enormous pressure of the surrounding iron. Therefore, the fracture of a pig of iron is generally an index of the rate at which it is cooled. If the suddenly cooled iron be re-melted and slowly cooled, it will assume all the characteristics of soft iron. The graphitic carbon will become plainly separated and large crystals will be formed. It may be stated that cast iron in a molten state is a solution of carbon and iron, and the mass is homogeneous.

Silicon in itself confers no benefit on cast iron. It is only its influence on the carbon contents that produces beneficial results. On the other hand, an excess of silicon renders cast iron absolutely unfit for use, making it very hard and brittle. A small quantity, through its action on the carbon, reduces shrinkage, increases strength and increases fluidity. Given, then, cast iron comparatively high in carbon with the proper amount of silicon and the ideal conditions are attained. The uses of phosphorus and manganese are too well known to require discussion and play no part in the method except as correctives. Keeping these facts in mind, it may be stated that an ordinary foundry iron very nearly fulfills these conditions, with the exception of sulphur. Molten cast iron is there-



ARBORS AND FINISHED CORES, READY FOR SETTING.



FINISHED PIPE BEFORE REMOVAL OF ARBOR.

ORIGINAL POURING DEVICE, LADLE IN HIGHEST POSITION.

VIEW OF MACHINE.

CASTING PIPES IN PERMANENT MOLDS.

fore a solution of carbon in iron with the addition of silicon, phosphorus, sulphur and manganese, all forming a homogeneous fluid mass. Now, if this mass be suddenly cooled, it is still homogeneous, the different elements not having time to segregate. If the cooling be continued at the same rapid rate until a temperature of about 1,600 deg. F. is reached, the iron becomes very hard and brittle. But if this sudden cooling is carried out only until the iron is set, and is then removed from the cooling influences, thus allowing the iron to lose its heat normally, the result is a structure whose fracture shows a very fine, close grain. It is tough, since all its particles are thoroughly interlaced, and it is strong because very nearly all the carbon is held in the combined state. In other words, it is homogeneous. Now, let us try to make this vital point plainer.

In a casting, such as a thin pipe, when cast in an ordinary sand mold, it requires about one minute to cool from the temperature of molten iron to the point at which the metal is set. It is in this period that the detrimental effects as shown in cold cast iron are produced. Phosphorus and sulphur and carbon segregate, and graphitic carbon is formed. Bear in mind that in this period the iron is in a liquid state with all its elements free to move. Once the casting is set, all segregation ceases, and the remaining carbon begins its beneficial work. As the iron loses its heat at a normal rate, annealing and carbide carbon are formed, both of which improve the quality of the metal. Now, if we suddenly shoot the molten iron into an iron mold, it sets very quickly, and the evil period is reduced in time from sixty seconds to two seconds—so short a time, in fact, that all the impurities are held in the position they occupied in the molten mass. The evils of sulphur and phosphorus are reduced to a minimum since they are in practically an atomic condition and are distributed evenly throughout the casting; and since no graphitic carbon is formed all the carbon exists as combined carbon, with a corresponding increase in its power for improvement. If the casting is removed from the cooling influence, in this case the iron mold, and allowed to cool normally, the ideal conditions are obtained. Chilling cast iron to the point of extreme hardness is purely a mechanical process, and the point to which the process of sudden cooling can be carried can be determined to an absolute certainty. It is simply a question of time. The data collected show that a 2-inch pipe can be removed two seconds after pouring, and should not remain in the mold more than six seconds. A 6-inch pipe can be removed in six seconds after pouring and should not remain more than twelve seconds. This time depends upon the thickness of the pipe walls. Very thin pipe would require not only a shorter time in the mold, but should be cast of iron higher in silicon. The reason for this is that silicon, by its action on the carbon, keeps the iron in a fluid state longer than normal Every foundryman knows there are irons in which it is impossible to form a chill, and there are other irons in which it is impossible to prevent it. The same limitations apply to making pipe as to the making of other iron products. A suitable iron must be provided if the very best results are to be obtained. This statement applies to any branch of the foundry business and is not set out as a new discovery. What is claimed and demonstrated is, that a poor iron is improved and rendered suitable for the work in hand.

(To be continued.)

IMMEDIATELY AFTER POURING.

Mold entering opening device, showing ends of core arbors and mold partially open.

LAWS OF FLIGHT.*

By F. W. LANCHESTER.

THE law of the pressure reaction for speeds such as may be usefully employed in aerial flight has been established experimentally, and is: (1) On a body of stated geometrical form in given presentation, the pressure reaction varies approximately as the square of the velocity, and as the square of the linear dimension. The theoretical justification of this law is that the viscosity and elasticity of the fluid as quantities of which the resistance is a function, are without sensible influence. This is approximately true, first concerning viscosity, so long as the product of the linear size and velocity of the body is greater than a certain minimum value; and secondly, as to elasticity, provided that the velocity does not approach too nearly the velocity of sound. In aerial flight as practised by birds or man, neither of these limitations applies, so that the V-square law may be accepted as applicable. There is some correction required in regard to skin-friction; in resistance of this kind it would appear that the index is somewhat less than 2, though how much at present we do not know. In the relations of the pressure reaction on planes at small angles there is a law of great utility to be deduced from experiment, namely, (2) for a given velocity the pressure varies directly as the angle. This law only applies to the small angle, i. e., to one in which, expressed in radians, the angle, its sine, and its tangent are sensibly equal to one another. The law further does not apply to planes in apteroid aspect, in the extreme case of which the sine-square law of Newton can be shown to apply; neither of these limitations seriously affects the validity of the law in relation to aerial flight. A theory founded on the hypothesis of constant sweep—that is, upon the assumption of a layer of air of defined thickness uniformly handled by the aeroplane—gives results in agreement with these two laws, but with a defect in the constant by which the quantities are related. This defect is accounted for and the theory is rectified by taking into account the cyclic component in the periptery; by this extension of the initial hypothesis complete harmony is established between theory and experiment. The two laws so far established result in the fact discovered by Wenham and rediscovered by Langley, that neglecting skin-friction and other direct resistance, the power expenditure decreases when the velocity is increased, and the law of frictionless flight is established. (3) Neglecting skin-friction and other direct resistance, the horse-power varies inversely as V, or the resistance to flight varies inversely as V^2. The modifying influence of skin-friction and of other resistances varying directly as V^2 results in the following laws, the proofs of which are given in the author's "Aerial Flight," vol. I., "Aerodynamics." (4) The total resistance to flight is least when the resistance due to aerodynamic support $\left(\propto \frac{1}{V^2}\right)$ is equal to the direct resistance ($\propto V^2$); hence this is the condition of greatest range on given fuel-supply. (5) The flight will be sustained for the longest time on a given supply of energy, when the resistance due to aerodynamic support is three times the direct resistance. (6) The speed of greatest range is $\frac{1}{\sqrt[4]{3}}$ (= 1.315) times the speed of least power. (7) Neglecting "body resistance" for aerodromes or aerodones designed for least resistance, the resistance is independent of the velocity of flight. In other words, the gliding angle is constant, or the power varies directly as the velocity of flight. Cor.: When body resistance is present the total resistance consists of two parts, one of which varies as the velocity squared and the other of which is constant. (8) That, consequent on laws 4 and 5, there are best values of angle β (the angle of an aeroplane to the line of flight, or the angle of trail of a pterygoid aerofoil), and of the P/V^3 relation, that correspond to the condition of least resistance. These, tabulated from theory, are found to be in harmony with experience.

An aerodone or aerodrome may be constructed to possess automatic stability without any special mechanism for the maintenance of equilibrium. The natural flight path is of undulating form, the varieties of flight path obtainable being demonstrated both by theory and experiment, plottings of these curves being given. An extension of the theory gives an equation, termed by the author the "equation of stability," and it is shown experimentally that this equation gives the limiting proportions of an aerodone of stable flight path. A final consequence of the theory of stability gives the important fact that for any given design of aerodone or flying machine there is a minimum velocity of stable flight, and that the larger the machine the higher this minimum velocity becomes. For a man-bearing machine, it is probably over 30 miles per hour, and in order that a sufficient margin of automatic stability should be provided, the flight velocity should be but little short of 40 miles per hour.

* Abstracted from a paper read before the British Association for the Advancement of Science.

ECONOMY OF A SELF-CONTAINED ENGINE AND BOILER.

REMARKABLE steam economy was shown by a German self-contained engine and boiler set tested recently by Prof. M. Gutermuth, of Darmstadt, Germany. Superheated steam and a compound engine having both cylinders seated in the smokebox and therefore jacketed by the hot flue gases, are the special features of the plant tested. Three tests, at 130 horse-power, 103 horse-power, and 78 horse-power, respectively, gave the following results: Steam consumption, 9.06 pounds, 8.86 pounds, and 9.56 pounds per horse-power-hour; coal consumption (with coal of 13,900 heat units per pound), 1.11 pounds, 1.06 pounds, and 1.13 pounds per horse-power-hour. The superheat at entry into the high-pressure cylinder averaged 236 deg. F., and at entry into the low-pressure cylinder (after the reheater), 200 deg. F. The total efficiency of boiler and superheaters was found to be 77 per cent, 78 per cent, and 78 per cent, respectively, while the mechanical efficiency of the engine varied from 93 per cent to 95 per cent. The duration of the tests was 7 hours for each of the first two and 4 hours for the third test. It should be noted that the brake was attached to a countershaft driven by belt from the engine flywheel, and to obtain the engine brake power the results were increased by 4 per cent to make allowance for the belt loss and the bearing friction of the countershaft.

The plant which gave these results was built by R. Wolf, of Magdeburg. It has an internally-fired boiler (230 square feet heating surface and 7.3 square feet grate surface) and a tandem-compound engine seated on top of the boiler. Forward of the boiler is a long smokebox, in which are two coils of superheating tubes, a front and a rear one. The front set takes steam from the boiler and feeds the high-pressure cylinder, whose exhaust goes to the rear superheater section and thence to the low-pressure cylinder. The low-pressure exhaust goes through a feed-water heater before passing to the condenser. The smokebox extends upward above the top of the boiler shell and there incloses the engine cylinders. These are 7.9 inches and 15 inches in diameter by 15.8 inches stroke, and are fitted with piston slide-valves. They are set tandem, with the low-pressure cylinder at the rear. The crankshaft is near the front; it carries two overhung belt flywheels. The tests are reported in the Zeitschrift des Vereines Deutscher Ingenieure of October 3, 1908. This summary is from Engineering News.

FACING SANDS AND THEIR USE.*

VARIATIONS IN FACES AND HOW TO OBTAIN THEM.

BY WALTER J. MAY.

ON the surface of a mold the character of the surface of the casting depends, and by variations in the facing it is possible to obtain from a smooth to quite a granulated face to your casting. This is secured by grading the sand, and you can use sieves from 60-mesh to 16-mesh, or in some cases even 10-mesh, to grade the sand, according as you want smooth or rough faces to your work. Besides this, by adding meal or ground coal to the facing-sand in proper proportions, you can have perfectly clean and workable skins to castings of any metal, and there is no need to pickle or otherwise doctor either iron or yellow alloys before machining.

The quality of the sand, naturally, must be considered when preparing facings of any kind; but so long as the sand is of a refractory character, carries no more aluminous material than is required to bind it together sufficiently to mold properly, and is of even texture, that is usually all that is required. Some sands will be found to contain materials likely to act as fluxes, which cause fusion of the other portions; and these are not good sands to use where hot metals are concerned, as they are very liable to burn into the surface of the castings, thus rendering the use of machine tools difficult unless a heavy first cut is taken —a point which is not desirable economically, as both time and tools on the one hand, and metal on the other, have to be too freely expended. The color of molding-sand is not important so long as its general quality is good, and generally the color does not indicate quality.

In preparing facing-sand, it should be first thoroughly dried, and then be well pulverized to insure separation, and after this it should be passed through the grading-sieve, the rejections being again pulverized and passed through the sieve to prevent having an excessive amount of waste. Generally speaking, it is a good method to pass the whole of the sand to be dealt with through a ¼-inch square-meshed sieve before drying, as this removes stones and also insures an even distribution of all parts of the mass, a more regular body of fine material being then obtained when grading for size, as, although fineness is needed, yet this must be accompanied by the full content of the material, separation of constituents not being desirable.

For brass and yellow alloys a proportion of fine pea or bean meal should be added, this varying with the quality of the sand to some extent, from about 8 to 16 pints to the bushel of dry sand being required for ordinary work, with, in some cases, a rather larger amount for special work. This meal should be thoroughly mixed with the sand, and then the whole should be passed through the grading-sieve to insure complete incorporation of the parts. If kept perfectly dry, and in a dry place, this mixture will keep for some time, and this allows of a fair bulk being prepared at one time. When wanted for use, a sufficient quantity should be damped down over night, and on the morning of use it should be rubbed tough with a piece of board. According to the bulk of the castings to be made, a thickness of from half an inch to an inch should be used, the flasks being then rammed up with ordinary sand.

For iron, a mixture of new and old sand should be dried and graded, and to this from 8 to 15 per cent in bulk of ground coal should be added, the coal being first passed through the same grade of sieve as the sand. After being passed through the sieve dry, the sand should be damped down and trodden tough, after which it should be passed through a ¼-inch square-meshed sieve, and stored away for use. According to the bulk of the castings to be made, from an inch to three inches of facing-sand should be used, and this should prevent the sand burning into the metal. The proportions of the new and old sands will vary somewhat according to the strength and tenacity of the former, this being a point only determinable by those handling the sand.

In using the facing-sand, it should lie for an equal thickness over all parts of the pattern, preferably being sifted on through a ¼-inch meshed sieve. Probably the facing will fall in a conical heap as shown in Fig. 1, the sharp edges of the pattern being barely covered, and in such a case the casting will not come clean at the edges, while very likely there will be more or less sand burnt into the metal. This is avoided by shaping the facing-sand up as shown in Fig. 2, in which case the edges will be amply protected. When the facing-sand is in place, the box is filled with the ordinary sand in the usual way, with the ordinary amount of ramming, and on completion the box and mold in section would appear as in Fig. 3. For filling the boxes, an open-textured sand which will hold well is best, as it permits of the freer escape of the gases through the body of the mold. Venting will, of course, be done in the usual way; but still, there is a great difference in results caused by variations in the condition of the body of the sand.

As mentioned previously, the smoothness of the skin

FIG. 1.

of the casting or otherwise depends on the grading of the sand; but additional graining of the surface can be caused by the use of a thin layer of carefully-graded wood ashes or other quite refractory material dusted over the pattern before the facing-sand is sifted on. Such things would not be used for castings which have to be machined as a matter of course; but for some purposes they come in handily.

The real purpose of using facing-sands is to prevent the sand burning into the casting, and to produce the required finish on the surface; but beyond the use of facing-sands there is also the use of "blackings" of various kinds—charcoal, mineral carbon, plumbago, smoke from oil-lamps or specially-made smoke-torches, and steatite—to be considered, these being used chiefly to insure that the sand shall part more freely from the casting, and also, in some cases, leave a polished surface. Sometimes these things are used with water, and sometimes in a dry state; but generally, to get

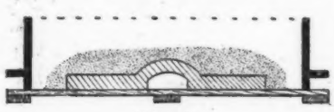


FIG. 2.

the best results, dry applications put on lightly through a cloth, and sleeked down with either tools or a soft brush, give the best finish to the castings. As a rule, for fine work, either plumbago or steatite in extremely fine powder, or the carbon deposited from smoke, will give the best finish; while for heavier work either mineral carbon or plumbago should be used, charcoal and wet blackings being only put on where machining has to be done. Properly used, the more expensive blackings do not cost more than a mere trifle; but when just plastered on anyhow, not only do they become expensive, but they damage the castings as well.

Where plaster or metal molds are used, facing-sands do not come in; but some facing has to be worked over the face of the mold, such things as chalk, plumbago, lampblack, steatite, and the like being used, according to the fancy of the operator and the purpose for which the molds are to be used.

With ordinary care, and by the exercise of skill and

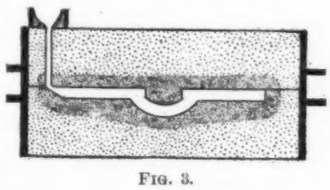


FIG. 3.

patience in preparing the molds, by using properly-graded facing-sands, it is possible to produce castings which require only the minimum of dressing or machining; but, owing to the labor which this kind of work involves so far as the foundry is concerned, cut rates cannot be quoted for it. Savings in other departments, however, amply repay the extra foundry costs, and where a work runs its own foundry this should be considered, as usually a large amount of unnecessary—and useless—machining is caused through trying to cut down charges in the foundry.

The cost of producing an article does not depend on saving costs in one department and spending more in others, but rather in arranging that the total costs on the article shall be generally reduced when finished; and if by raising the cost in any department, say, 10 per cent, we save 15 per cent on the total cost, it is just at that point that the real economy takes place. If work is done really well in the originating departments, all other departments do their share of the work more cheaply; and as usually all metal work originates in either the foundry or smithy, these two departments should not be run on cut lines.

*From the English Mechanic and World of Science.

AMERICAN PETROLEUM—ONE OF OUR BEST ASSETS.

ACCORDING to Dr. David T. Day of the United States Geological Survey, in a report just issued, the production of American petroleum in 1907 calendar year was 166,095,335 barrels, valued at $120,106,749. Since 1859 the United States has produced 1,806,608,463 barrels, worth $1,654,877,685. This year will bring the production for thirty-nine years up to 2,000,000,000 barrels, with a more than proportionate increase in the total value, as oil is not getting cheaper, but the contrary, owing to the large and rapidly increasing demand for crude petroleum for manufacturing, railway, and ship fuel purposes.

Since the discovery of petroleum in various States the total productions have been:

States.	Barrels.
Pennsylvania and New York since 1859	687,425,409
Ohio, since 1876	336,250,105
California, since 1876	201,965,825
West Virginia, since 1876	185,039,718
Texas, since 1889	117,819,901
Indiana, since 1889	90,127,511
Kansas, since 1889 (and Oklahoma since 1905)	85,881,278
Illinois, since 1889	28,866,683
Louisiana, since 1902	27,413,511
Colorado, since 1887	8,874,285
Kentucky and Tennessee, since 1883	5,276,578
Oklahoma, from 1891 to 1904	1,560,313
Wyoming, since 1894	85,785
Missouri, since 1889 (including Michigan)	21,471
The oil States got for their oil in 1907:	
Oklahoma and Kansas	$18,478,658
Pennsylvania	17,579,706
Illinois	16,432,947
West Virginia	15,852,428
Ohio	14,769,888
California	14,699,956
Texas	10,401,863
Indiana	4,536,930
Louisiana	4,063,033
New York	2,127,748
Kentucky and Tennessee	862,396
Colorado	272,813
Utah, Wyoming, Michigan, and Missouri	28,383

THE CITY OF LYONS'S NEW CURRENT SUPPLY.

ONE of the largest enterprises in the way of securing a supply of electric power for a leading center has been carried out in France, where it was desired to obtain a certain amount of current for use in the city of Lyons. The present undertaking is of a unique character owing to the fact that the overhead power line is operated on the direct current system at high tension, using for this purpose the type of electrical machines which was devised by M. Thury of Geneva. The power is obtained from a 200-foot fall in the Isère River, which lies at 110 miles distance from Lyons, and in the first part of the enterprise there is about 6,500 horse-power transmitted in this way. What is noteworthy is the high tension of the power line. While in the case of alternating currents the limit seems to be not much above 70,000 volts, with the direct-current system it is possible to reach 100,000 volts, and this it is proposed to do when it comes to the extension of the present plant. During the first stages of the work it was found sufficient to operate it at 60,000 volts, and this will afterward be doubled. The turbine station is located on the Isère near Moutiers in the Savoy region. At Lyons the current is received in two stations which are erected for the purpose. One of these lies on the outskirts of the city and the other in the heart of the town, and the two are connected by a 2½-mile underground cable line. In the turbine plant there are erected four principal turbine-dynamo sets, each of which will give 1,600 horse-power. Each of the turbines drives four dynamos which are

mounted directly on the shaft, which is somewhat different from the usual practice, and what is still more unusual is that all the dynamos are connected in series on the main line, so that their voltages are added together, and in this way a total of 60,000 volts is produced from the 16 dynamos. Another point to be noticed is that the middle point of the series of machines is connected to ground. In the stations at the city are mounted sets of motors which are driven by the current of the main line, and they operate in turn a set of generators for giving the current supply for the city at low tension.

A KEROSENE MOTOR BARGE.

A NEW CRAFT FOR CANALS.

BY OUR ENGLISH CORRESPONDENT.

AN interesting development in canal traffic is being carried out in Great Britain, the results of which after several months' continuous service have proved so satisfactory that the system is to be extended. Several objections have been raised which have somewhat militated against the application of the internal-combustion motor to this class of traffic, the most important being the emission of the exhaust gases into the open air, which in the tunnels would accumulate and constitute a grave danger, more especially to the barges hauled by animal traffic. However, this disadvantage has been overcome by the invention of Mr. Edward Tailby, a boat builder of Birmingham. The patentee has adhered to the orthodox type of boat utilized for this class of traffic, since its design, as the result of several years' experience in Europe, has emphasized its practical suitability to narrow and shallow artificial waterways. It is precisely similar to the horse-drawn barge of this pattern, the only alteration being the provision of space for the installation of the motor and the screw propeller. The vessel has a total length of 71 feet by 7 feet beam, and is of 3 feet 8 inches depth. Her carrying capacity is 32 tons of heavy freight and 25 tons of timber. In the accompanying illustration the barge is shown loaded with timber transported from an incoming Canadian vessel at Sharpness Point on the river Severn, *en route* for Birmingham, 75 miles inland.

SELF-PROPELLING CANAL BARGE USING KEROSENE-MOTOR POWER.

The motor, which is of special design, is of the two-cylinder type, developing 15 horse-power, and constructed to run upon a low-grade kerosene driving a single-screw propeller, and can attain a speed of from 4 to 6 miles an hour in the canals, increasing to 8 miles upon the river Severn, the lower speed in the artificial waterways being governed by the extent of the wash and damage that may be caused to the banks thereby. Even at its lowest speed this craft shows a decided advance upon the speed of the average animal-drawn craft.

Owing to the topographical configuration of the country through which the waterway passes, the mechanical development of canal traffic in England is a matter of great difficulty. For instance, the distance from Birmingham to Sharpness Point is 75 miles, but for a great part of the distance between the two points, many difficulties in regard to locks and tunnels (both of which are numerous) have to be negotiated. For instance, after leaving Birmingham there is a clear uninterrupted run with the exception of tunnels for 13 miles; during the succeeding 13 miles no less than 57 locks have to be passed through. Then follows 30 miles of the river Severn to Gloucester, where the boat is locked into the Berkeley ship canal in order to reach Sharpness, where ocean-going vessels load and discharge their freight.

The motor barge has proved remarkably free from vibration, even when running at full speed. Owing to the simplicity of the mechanism, but two hands are necessary for its operation, one controlling the motor and the other the helm. It is very economical in running, the fuel consumption averaging one gallon of kerosene per hour at 10 cents per gallon, which is equivalent to about 1½ cents per ton mile. The extent of this reduced cost of operation may be better comprehended when it is recollected that the railroad charges for freight transportation between the two points averages 2.4 cents per ton mile.

During the past twelve months the barge has proved eminently successful, a round trip between Birmingham and Sharpness, some 150 miles, easily being completed within a week, including time occupied in loading and unloading. The barge covers the whole journey under its own power, and on several occasions non-stop runs have been accomplished, traveling being maintained both day and night. The barge frequently leaves Birmingham empty and reaches Gloucester the same day, the journey of 56 miles being covered in fourteen hours, giving an average speed of 4 miles per hour, inclusive of the delays occasioned by passing through the intervening fifty-seven locks.

The barge has proved especially useful at those times when the Severn is in flood. The general practice with the ordinary barges is steam towing over the thirty miles of the river Severn between Worcester and Gloucester. When the waterway is in flood, however, the service is brought to a standstill, owing to the river level being too high to permit the tugs to pass beneath the bridges. This was strikingly demonstrated recently, when the river was 13 feet in flood, and all other traffic was held up for some time, while this motor barge maintained its usual service. The inventor has successfully overcome all difficulties in connection with propeller design and speed, water circulation for cooling the engine, exhaust and other troubles, so that the system is now completely and financially practicable. The boat carries 88 gallons of fuel, there being a reservoir placed over the screw of 44 gallons capacity, while another barrel of 44 gallons is kept in reserve. The total running charges for the 150-mile round trip, including wages of engineer and helmsman, aggregate $5.08, as compared with some $13 for a horse-drawn barge. The patentee is now designing a barge fitted with a single-cylinder engine of greater speed. Efforts are being made to extend the system, since the lower canal charges are of great importance to shippers, more especially as it is found that a 15-horse-power motor can not only propel a weight of 26 tons at 4 miles per hour, but can also haul a second barge of similar carrying capacity at practically the same cost and speed. Motor canal traffic has many distinct advantages over electric traction, since not only is it cheaper, but the initial outlay is lower, while each craft is rendered an individual unit, so that in the event of breakdown the whole system is not disorganized, but only affects the particular boat involved. Consequently, there is no serious interruption of the traffic. In this particular instance, however, the barge has proved eminently reliable in operation, no breakdowns having occurred during the journeys.

THE SCIENTIFIC STUDY OF HEREDITY.

MUCH work has been done to secure improvement by the cross-breeding or hybridizing of different varieties. It was Darwin again who was the first broadly scientific investigator of such inheritance. Take two plants or two animals which differ in one or more qualities and cross them, then it is to be expected that the hybrids will differ from the parents, and that a new strain or breed may be obtained that will prove more favorable for our particular purposes. Much of this kind of experimentation, perhaps the greater part, has been done so far by practical animal breeders and gardeners, and it was from such records that Darwin obtained much of his information. No one, for instance, has carried it out more extensively than Burbank, and he has had in mind marketable returns. Yet the theoretical study of hybridizing is coming to aid the other, and in time may come to direct it. Different kinds of inheritance are now distinguished, as blended inheritance, when the hybrid is intermediate between the two parents; mosaic, when it has some of the characters of the one and some of the other; alternate, when some of the hybrids are like one parent and some like the other; and the so-called unisexual inheritance, when all the hybrids tend to resemble one particular parent. Entirely new and unexpected fields of experimentation have been brought out by Mendel's study of alternate, and De Vries's examination of unisexual inheritance. This theoretical work also teaches that in practice attention should be given not so much to the whole individual as to the particular quality desired. The remarkable work of De Vries, the most important in evolution since the time of Darwin, would tend to show that though new forms may be produced by crossing, such crosses are usually not permanent, but tend to revert. De Vries's particular contention is that stable new forms, those that breed true, are not produced gradually by selection or otherwise, but arise suddenly and only in particular mutation periods. This introduces an entirely new attitude in the matters of selection and cross-breeding, and there can be no doubt that the scientific decision of these great problems will come to exert a great influence upon the progress of agriculture. It is the work of theorists that is here directing, stimulating, and explaining, and it is changing the present haphazard experimentation, with its great loss of time and money, into accurate control.

If farmers would only do a little experimenting on their own account, each laying aside a small piece of ground for making tests, they would learn more of practical advantage than by following, year in and year out, the methods handed down by their forefathers. They would be doing a little scientific explanation, and though this might not immediately give them an additional bale of cotton, in time it would give them much more than that and would fill them with greater interest for their daily labors. The farmers are the backbone of the nation, and that spine must not get the rheumatism. A man must look before he leaps, and science does the looking. As Franklin put it: "The eye of a master will do more work than both his hands." Indeed, the farmer comes into close touch with biological problems because his business is directly with plants and animals, and though he does not know it he is really a biologist in the rough. When the competition for market becomes keener, and it continues to do so as men become more trained, only he will be able to succeed who is armed with a working theory and by means of it aims at better results. In farming it is not the land so much as the man. To get at a new plan so as to use his time and brawn to the best advantage, the farmer must begin to explain and must use the explanations of science. A hen can not grow into a rooster, but it can be made to lay two eggs a day. The question of the qualities and possibilities of living beings is the subject-matter of biology, and the more we understand them the more we can use them. But we must remember that we can apply only when close study has suggested a method, and for that preliminary study to be effective it must not be hampered by the thought of immediate practical returns. Had Darwin in mind the improvement of domestic races of pigeons and poultry instead of the explanation of their origin, he would have contributed much less than he did to be put to practical use. Therefore the farmer should cease to look upon biology as an expense and luxury meant to entertain rich men's sons; he should recognize that any laboratory that is helping to analyze the energies of life is contributing something, indirect but none the less important, to further our usage of plants and animals.—Popular Science Monthly.

THE SKIN MOULT OF A CATERPILLAR.

THE CHANGES FROM CATERPILLAR TO MOTH.

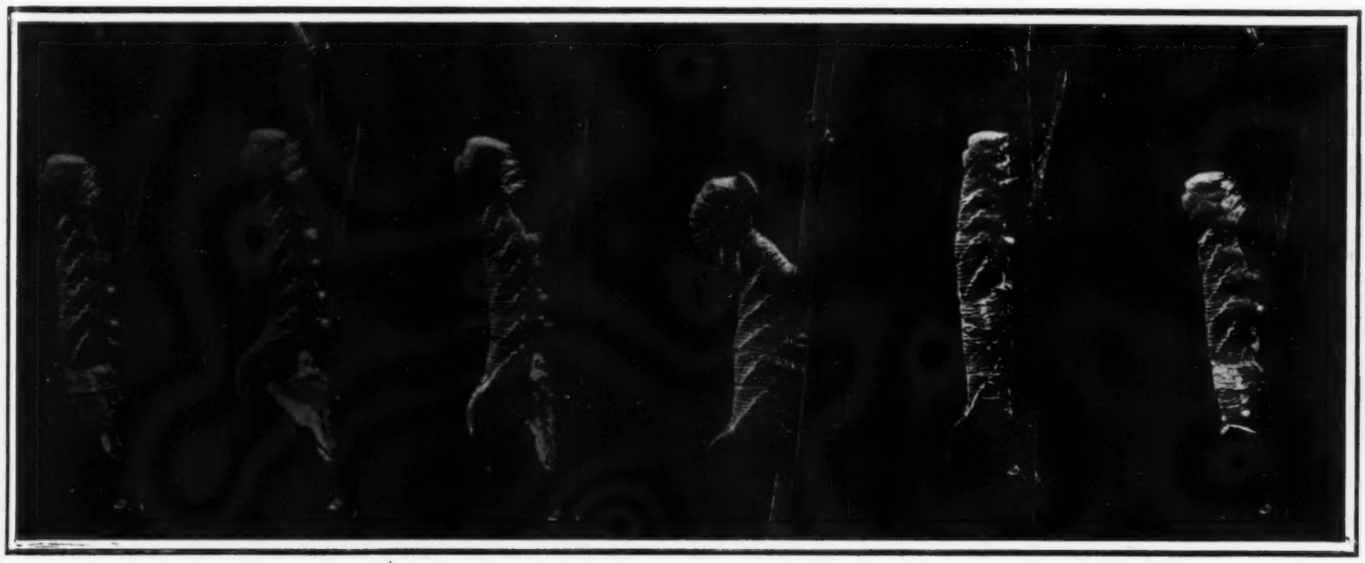
BY WILLIAM FARBEN.

THE chief changes which moths and butterflies undergo in their development are well known to all—the passing from caterpillar to chrysalis and from chrysalis to moth—well known so far as that these changes occur in succession. Their comparative importance is not so generally understood. As the gradual development, which is going on during the whole of the active life of the insect, reaches certain stages, it is marked by more or less abrupt changes in its outward appearance, these changes being revealed in the case of the caterpillar by a shedding of the outer skin, and of the chitinous covering when the perfect insect emerges from the chrysalis. The nervous, respiratory, digestive, and reproductive systems are modified to suit the life of the insect in its different stages; but these various systems are always present. In the caterpillar stage, when practically all the feeding and growing take place, the digestive organs are paramount; they do not disappear in the perfect or winged state, but become of importance secondary to that of the reproductive system. These are the two important stages—the caterpillar, feeding and growing, and the winged or perfect stage, reproducing. The chrysalis is merely the winged stage in a dormant condition, the chief value of which, in the life history of the insect, is to bridge the seasons. The chrysalis is not, as popularly regarded, a hard shell in which the perfect insect gradually takes form. When the caterpillar skin is finally discarded, the insect is, to all intents and purposes, a moth or butterfly, as the case may be, with wings, legs, antennæ, and proboscis all neatly folded along its ventral or under surface. By careful observation of full-grown caterpillars at the change, the limbs and wings of the newly-revealed insect may be seen for a short time before the semi-transparent jelly-like substance with which the whole is covered darkens and hardens into the chitin which forms the well-known outer coating of the chrysalis. It is only in the few days preceding the emergence of the winged insect that further development takes place, the long time spent in the chrysalis stage being, as before stated, merely a dormant period of convenience for bridging the seasons. A butterfly which remains in the chrysalis nine or ten months, from the end of one summer to the beginning of the next, need not, so far as the requirements of development are concerned, and on occasion does not, remain in that state longer than nine or ten days.

I have said that the various transformations or sudden changes in the insect's appearance are revealed by the casting of the outer skin or of the chitinous covering. The process of moulting the epidermis of the caterpillar is known as "ecdysis," but it is not only at the change from caterpillar to chrysalis that this occurs; there are several skin moults (in number varying in different species from four to six, or more) during the life and growth of a caterpillar. The head and limbs do not in growth keep pace with the body, their increase in size being gained at each skin moult. When the little caterpillar first hatches from the egg the body is very thin and small, and the head and limbs, in proportion, very large. At the end of a week's feeding the body has, in size, caught up the head and limbs; the caterpillar then ceases to feed, and spinning a thin pad of silk on a leaf or stem, attaches itself to it by fixing the tiny hooks on its claspers to the silk; it then remains quiescent for a period varying from twelve to forty-eight hours. During this time the epidermis shrivels and becomes separated from the inner skin, considerable muscular contraction takes place, and toward the end the caterpillar becomes restless, generally oscillating sharply from side to side; the skin then splits on the back near the head, and the caterpillar gradually works itself free, completing the moult by crawling out of the old skin, which remains attached to the silken pad.

The head and legs will be seen to have gained considerably in size, being large in comparison with the body, which is thin and cadaverous-looking. The discarded skin often forms the first meal, and then the food plant is attacked voraciously, and in about a week the caterpillar will be ready for another moult. In some species the caterpillars assume a quite new color and pattern after a moult, presenting an entirely different appearance. In fact, it is only at the moult that any alteration in the caterpillar's appearance takes place; there is no gradual change. Although growth proceeds at great rate during the moults, it is only after the final moult that the highest rate of increase is attained.

Two years ago I reared from eggs a number of caterpillars of the privet hawk moth, in order to observe and obtain photographs of the "ecdysis." As I shall have to speak of the various parts of the caterpillar later on, a general description at this point will facilitate matters. The privet hawk caterpillar is a bright velvety green, with seven oblique pink stripes on each side. The body is divided into thirteen segments, of which the head forms the first. There are three pairs of legs on the three segments immediately next the head. These are called prolegs, and are the true legs of the insect. It is these same three segments which bear the wings and legs in the moth stage. The fifth and sixth and eleventh and twelfth segments have no legs; but on the seventh, eighth, ninth, and tenth are four pairs of claspers, or membranous legs, each pair on a separate segment. These are not true legs, although it is with them that the caterpillar does most of its walking and clinging; they are sucker-like prolongations of the skin, having a series of little hook-like spines on the ventral surface, and exist only in the caterpillar stage. On the thirteenth, or anal, segment is a pair of claspers, larger than the others, and with more tenacious clinging power. The twelfth segment carries on its upper surface a horn-like process which is characteristic of the caterpillars of nearly all hawk-moths. This horn, most highly developed in the species at present under consideration, is hard, black, and shining. The brood of caterpillars I had under observation moulted their skins five times at intervals of about six days. They were kept well supplied with fresh food, and varied very little in rapidity of growth, all being ready for the final moult when about thirty days old and 1½ inches long. They then ceased feeding and settled themselves on stems of privet in the cage. They rested in the characteristic sphinx-like attitude, clinging tightly with their claspers, and carrying the forward part of the body raised. At the end of twenty-four hours the front part of the body, by contraction of the muscles of the back, became still more elevated, the prolegs and head being tightly bunched together by reason that the segment-bearing legs and claspers contract on the under-surface, giving a humped appearance to those segments. Later, the skin becomes shriveled, the soft, even texture giving place to a dull shagreen-like appearance. On the second day, when the moult is imminent, the contraction is seen at its height, and is represented in our fourth illustration, which shows also that what was the head of the insect is now but a shell, the head itself having receded within the epidermis of the body, where, considerably enlarged, it may be seen outlined behind the old head-shell. This caterpillar went through its moult so rapidly that I failed to obtain further photographs of it, the other five, which show the various stages of the moult, being portraits of another individual which occupied a little under ten minutes from start to finish. It was not easy to judge exactly when a caterpillar would commence to moult, and many attempts to obtain photographs resulted in failure from one cause or another. I would place in position a caterpillar which appeared to be ready to moult, and have camera and plates prepared and the specimen carefully focused, then while waiting I would often have the mortification of seeing others, which had not appeared to be so forward, cast their skins; or after waiting and watching an hour more, I might be called away for a few minutes and return to find my "sitter" had completed its moult. However, this all makes for the sport of nature photography, and I was rewarded at last, for directly I had focused on the caterpillar shown in the accompanying pictures, it commenced to moult. The first indication was a violent twitching and oscillation from side to side, followed by the sudden dropping off of the old head-shell; at the same time the skin split all along the back of the first two or three segments, and slipped suddenly down to the first or second pair of claspers, the elevated part of the body straightening out as soon as released. The fifth illustration represents this stage. The caterpillar now commenced to walk slowly out of its skin, in which walk it used only the claspers, the true legs being held clear of the stem,



Still emerging. Releasing anal claspers. Free; resting on old skin. Ready to moult. First stage of moult. Walking out of skin.

THE SKIN MOULT OF A CATERPILLAR.

The position of the first clasper compared with that of the leaf stalk on the opposite side of the stem shows the distance traversed in the process; in the fifth picture the clasper is below, and in the second and third above, the leaf stalk. The sixth shows the skin just passing the third clasper, and the first, perhaps the most interesting photograph, was taken just as the horn-like process was being withdrawn from its sheath.

In this one the markings are plainly visible on the puckered and partly-discarded skin. The second shows the anal claspers being lifted from the skin. Compare now the difference in texture and boldness of the markings of the new skin in those of the second caterpillar with the old skin of the one in the fourth illustration, and note also the enormous increase in the size of the head, legs, claspers, and horn. It is not merely the external skin which is cast; part of the lining of the alimentary canal and of the mouth and gullet, as well as some of the larger breathing tubes, also comes away. The orifices of the breathing tubes may be seen as upright oval depressions, one on the side of each abdominal segment.

After the moult the privet hawk caterpillars almost invariably turned round and rested for a period of two or three hours head down before commencing to feed, during which time they underwent a rapid development, or ripening of color. After the rest following this final "ecdysis" the caterpillars attacked the privet leaves with what may be described as voracious appetites. They almost seemed to realize that all tiresome moulting was at an end, and that nothing lay before them as caterpillars but a glorious ten days' feast on privet leaves, that their one duty in life was to feed and grow, and I must say that seldom is an obligation in any form of life more assiduously discharged. There was a period of eight or ten days in which to fill out that loose skin, and to grow a body which should be less of a disgrace to that preposterously large head and limbs. How well they succeeded was adequately shown by one fully grown, whose body had lost all its creases, and whose portly figure was so full as to make it appear to find it necessary to stand upon tip-toes.

For those who love statistics, it has been found that a privet hawk caterpillar at the time of its final "ecdysis" weighs about 20 grains, and in eight or ten days, when fully grown, it has increased to 120 grains, an increase which sinks into insignificance when we take into consideration its weight when it first leaves the egg-shell of one-eightieth of a grain, or that in the thirty or thirty-two days of caterpillar life it increases its weight some 10,000 times.—Country Life (London).

RECENT ASTRONOMICAL RESEARCH.*

A RECORD OF RECENT PROGRESS.

BY C. G. ABBOT.

I. ACTIVITY IN SOLAR INVESTIGATION.

EACH periodic return of the time of maximum sun-spot occurrence brings with it a freshened interest and renewed activity in solar observations. This revival of solar research has been uncommonly marked of late, and promises a steady and fruitful continuation of work, even now that the sun-spot maximum has passed. Two important international conferences to consider solar research have been held, the first at St. Louis in 1904, the second at Oxford, England, in 1905, and an "International Union for Co-operation in Solar Research" has been formed. The success of this promising movement has been principally due to the efforts of Prof. George E. Hale and Prof. Arthur Schuster, who by extensive correspondence and personal intercourse with astronomers and physicists, and by obtaining the support of the International Association of Academies, secured a good attendance of men of ability at the two conferences just mentioned.

To understand the objects of the Union, it may be recalled that notwithstanding that the sun is the promoter of life on the earth, the controller of climate, and the only star which is near enough to admit of detailed study, yet observation of this, the most important celestial object, has hitherto been chiefly limited to eclipse observations, estimations of sun-spot numbers, appearance of the prominences, regulation of time, and occasional observations of peculiarities of spectrum, time of rotation, and distribution of brightness. The nature of sun-spots, the cause of their periodicity, their level as compared with the photosphere, the cause of their drift over the surface of the sun, the nature and thickness of the envelope which absorbs the solar rays, the exact wave lengths of the lines in the solar spectrum, the nature of the corona, the amount of the solar radiation available to the earth, the question whether solar radiation is constant or variable in amount, the connection between terrestrial magnetism and solar activity, the dependence of the earth's climate on the solar radiation, the temperature of the sun's surface, the question as to the source of the heat of the sun—all these and doubtless other questions of equal interest are still in dispute.

The Union seeks to foster a spirit of interest in solar research; to suggest needful investigations; to avoid unnecessary duplication of work; to promote, where desirable, uniformity of methods of reduction of observations; and especially to encourage solar observations in regions of the earth where they have hitherto been neglected, so as to tend to keep the sun always under observation, that no unusual and interesting phenomenon may escape being recorded. Besides these general activities the following special subjects were discussed and are receiving the attention of expert sub-committees appointed at the Oxford meeting:

Standards of Wave Length.—The first absolute measures of the wave length of light were made by Sir Isaac Newton about the year 1704, although he did not recognize light to be propagated by waves at all, and interpreted his results in accordance with the corpuscular theory. The first advance came with the invention of the diffraction grafting by Fraunhofer in 1815, and his measurements of the wave lengths of the principal lines of the solar spectrum were the standards till 1868. In that year Angström published the first map of the solar spectrum upon the normal or wave-length scale, basing the wave lengths upon his own determinations. In recognition of his great work, wave lengths have generally been stated since his time in the so-called "Angström's units," or ten-millionths of a millimeter. Thus the wave lengths of the yellow lines of sodium are near 5,890 Angström units.

Twenty years later a new era of spectroscopy was made possible by the work of Rowland. After inventing devices for correcting the errors in the cutting of screws, and other devices for correcting the errors which would be introduced in actual ruling by the errors left outstanding in the most perfectly corrected screw, he ruled diffraction gratings of an order of excellence and size till then unapproached and only very recently excelled. He invented also the concave grating, and showed how it might be used in the spectroscope without additional aid of lenses or mirrors to focus the rays.

There is a characteristic of the grating spectrum which was used by Rowland, Langley, and many others for connecting (as was supposed, rigidly) the wave lengths of different spectral rays. This consists in the fact that a large number of spectra are thrown by the grating in the same direction, so that if light of wave length 7,000 Angström units was found in the spectrum of the first order at a certain point, there would be at the same point light of $7000/2$, $7000/3$, $7000/4$, . . . Angström units in the higher orders of spectra.

Aided by this relation and employing the new and unexcelled concave gratings, together with photographic plates of the finest grain which he made for the purpose, Rowland photographed the spectrum of the sun and that of numerous metals as produced in the electric arc, giving the wave lengths generally to thousandths of an Angström unit or to seven places of figures. The publication of these results, including thousands of spectrum lines hitherto unrecorded, together with very numerous statements of the coincidences of solar and metallic lines, was thought at the time to be the last word on the subject of standard wave lengths which would be needed for many years. Rowland, however, did not determine the absolute scale of his system of wave lengths, but based it on the measures of the wave length of the D lines made by Bell and others, and himself observing by the method of coincidences, as above explained, stood sponsor only for the relative accuracy of the measures throughout the spectrum.

In 1893 Michelson and Benoit, by the aid of the Michelson interferometer, which, though based finally on the same principles as the grating, is yet wholly different in its make-up and use, determined the absolute wave length of the red ray of cadmium in terms of the standard meter. These results proved that Bell's value of the wave length of D, adopted as the basis of Rowland's system, was too large by about two-tenths of an Angström's unit. A little later it was shown by Jewell that there is a lack of exact coincidence between solar and metallic spectrum lines, and about the same time it was shown by Humphreys and Mohler that pressure played a part in determining the apparent place of lines. About 1900 Kayser discovered that Rowland's tables were not exactly consistent in themselves, for it made a difference, whether the observer measured to one or another of Rowland's lines, what wave length he would assign to some line intermediate between them.

About this time, Michelson proved mathematically that certain errors in the ruling of gratings are possible, which destroy the exact validity of the method of coincidences, so that a line of given wave length in the first-order spectrum does not necessarily absolutely coincide with one of half that wave length in the second-order spectrum. Kayser immediately tested this conclusion practically with two large Rowland gratings in his possession, and found differences of as much as 0.03 Angström unit traceable to this cause.

Thus in the course of fifteen years after the publication of Rowland's spectrum maps it was found that the absolute scale of wave lengths he had adopted was in error by 0.2 Angström unit and, what is far more serious, there exists a source of error unsuspected till recently, which has introduced inconsistencies of several hundredths of an Angström unit in the relative accuracy of Rowland's tables.

These conclusions are independently certified by comparison of Rowland's numbers with the apparently highly accurate determinations of wave length of numerous lines made by Messrs. Pérot and Fabry with their special interferometer.

To the general reader it might seem a matter of indifference that defects amounting to only one part in 250,000 should exist in the relative accuracy of the wave lengths of different solar and metallic spectrum lines, but important conclusions in at least three different lines of research depend on these small differences. First may be mentioned the determination of the motions of heavenly bodies in the line of sight of the observer, which depend on the measurement of the shifting of the lines of their spectra. In this work an error of 0.02 Angström unit in the wave lengths corresponds to a difference of velocity of more than a mile a second. As another research demanding accurate standards of wave length may be mentioned the comparison of metallic and solar or other celestial spectra, for the purpose of determining the constitution of the heavenly bodies. It has often occurred heretofore that erroneous theories of the broadest scope have been based on a supposed coincidence of spectral lines, which truly were of very slightly differing wave length. Thirdly, the investigations of regularities in the distribution of the different spectral lines of an element, on which may rest important theories of the inner constitution of matter, would be vitiated by errors of the wave lengths such as have been noted.

It has been decided by the Union that a new system of wave lengths is necessary; that it shall be based on the wave length of a suitable spectrum line, to be fixed permanently, in units differing as little as possible from 1/10,000,000 millimeter, and to be called Angström units; that secondary standards shall be determined by an interferometer method at distances not greater than 50 Angström units apart, and the source of light for the determination shall be produced in the electric arc of 6 to 10 amperes; that tertiary standards shall be selected at distances of 5 to 10 Angström units whose wave lengths shall be determined from the secondary standards by the aid of gratings. This work was placed in charge of a committee of expert spectroscopists, and progress is reported from several laboratories in making the measurements required.

II. VARIATION OF LATITUDE AND THE WANDERING OF THE POLE.

While the possibility of latitude variation was recognized from the careful work of European observers as early as 1885, the actual discovery of the variation and of the laws which govern it are the work of an American astronomer, Mr. S. C. Chandler, carried through in the face of the opposition of long-accepted theory and of the opinions of astronomers in general. It will be interesting to recall briefly some of the steps and conclusions involved in this remarkable discovery.

*Smithsonian Institution's Annual Report.

The phenomenon in question has, of course, no connection with precession or nutation, but is concerned only with a variation of the position of the axis of rotation of the earth within the earth itself. Its effect is to periodically increase the latitude of places on one side of the earth and simultaneously diminish that of those on the opposite side of the earth by amounts of the order of 30 or 40 feet. In other words, the pole is 30 or 40 feet nearer Washington, and the same farther from Peking at one time than another.

Mr. Chandler's first announcement of his discovery in 1891 began as follows:

"In the determination of the latitude of Cambridge, Mass., with the Almucantar about six years and a half ago, it was shown that the observed values, arranged according to nights of observation, exhibited a decided and curious progression throughout the series, the earlier values being small, the latter ones large, and the range from November, 1884, to April, 1885, being about four-tenths of a second. There is no known or imaginable instrumental or personal cause for this phenomenon, yet the only alternative seemed to be an inference that the latitude had actually changed. This seemed at the time too bold an inference to place upon record, and I therefore left the results to speak for themselves."

He gives further data of his own on the subject tending to support the hypothesis of a change of latitude, and then refers to European observations contemporaneous with his own as follows:

"Curiously enough Dr. Küstner, in his determination of the latitude from a series of observations coincident in time with those of the Almucantar, came upon similar anomalies, and his results, published in 1888, furnish a counterpart to those I had pointed out in 1885. The verification afforded by the recent parallel determinations at Berlin, Prague, Potsdam, and Pulkowa, which show a most surprising and satisfactory accordance as to the character of the change in range and periodicity with the Almucantar results, has led me to make further investigations on the subject."

Mr. Chandler then proceeded to give detailed results of the investigations, which he summed up as follows:

"The general result of a preliminary discussion is to show a revolution of the earth's pole in a period of 427 days, from west to east, with a radius of 30 feet, measured at the earth's surface. Assuming provisionally, for the purpose of statement, that this is a motion of the north pole of the principal axis of inertia about that of the axis of rotation, the direction of the former from the latter lay toward the Greenwich meridian about the beginning of the year 1890. This, with the period of 427 days, will serve to fix approximately the relative positions of these axes at any other time for any given meridian. It is not possible at this stage of the investigation to be more precise, as there are facts which appear to show that the rotation is not a perfectly uniform one, but is subject to secular change, and perhaps irregularities, within brief spaces of time."

These results of observation fell squarely across the long-accepted theory of Euler, according to which the variation of latitude, if any, must be a uniform one of ten months, and also contradicted the result of careful reduction of excellent observations from which it had been concluded that no sensible wandering of the pole did in fact take place. The theoretical difficulty was, indeed, soon partly removed by Prof. Newcomb, who pointed out that the fluidity of the ocean and the elasticity of the earth had been neglected in deriving ten months as the theoretical period of a possible rotation of the earth's pole, but at the same time he professed himself unable to account on the principles of dynamics for a variation of the period of the inequality, unattended by an alteration of its amplitude during the preceding half century, conclusions which had come from recomputations which Mr. Chandler had in the meantime made of the classic observations of Bradley in 1728, and others of different periods of the nineteenth century.

Under the spur of the theoretical difficulties stated by Prof. Newcomb, Mr. Chandler collected an immense mass of evidence on the subject, involving the reduction of more than 33,000 observations made by nine different methods, comprising the work of seventeen observatories, distributed over both the northern and southern hemispheres, and covering the interval of time from 1728 to 1890. From this great array of evidence the fact of the wandering of the pole was not only clearly confirmed, but also the variation of its period and amplitude came out without question, and an insight was gained as to the causes of this baffling phenomenon as follows:

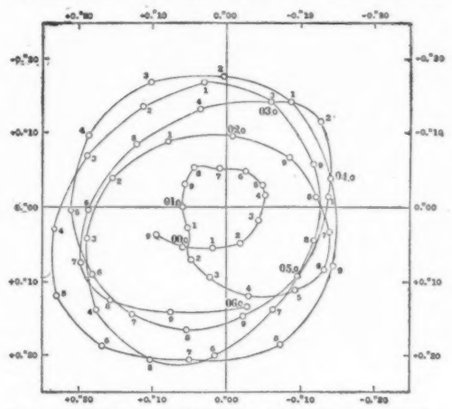
"The observed variation of the latitude is the resultant curve arising from two periodic fluctuations superposed upon each other. The first of these, and in general the more considerable, has a period of about 427 days, and a semiamplitude of about 0.12 second. The second has an annual period with a range variable between 0.04 and 0.20 second during the last half century. During the middle portion of this interval, roughly characterized as between 1860 and 1880, the value represented by the lower limit has prevailed, but before and after these dates, the higher one. . . .

"As the resultant of these two motions, the effective variation of latitude is subject to a systematic alternation in a cycle of seven years' duration, resulting from the commensurability of the two terms. According as they conspire or interfere, the total range varies between two-thirds of a second, as a maximum, to but a few hundredths of a second, generally speaking, as a minimum.

"In consequence of the variability of the coefficient of the annual term above mentioned, the apparent average period between 1840 and 1855 approximated to 380 or 390 days; widely fluctuated from 1855 to 1865; from 1865 to 1885 was very nearly 427 days with minor fluctuations; afterward increased to near 440 days."

Mr. Chandler expressed these results mathematically by an equation in which the variation of latitude is given as the sum of two periodic terms, and he found that this expression very closely represented all the observations he had so laboriously collected.

The valuable consequences of this discovery of Mr. Chandler's are numerous. First of all, they showed why certain series of observations made with the most painstaking care at the national observatories of the United States, Great Britain, and Russia had exhibited discordancies which had led to distrust of the very best pieces of apparatus, and had involved laborious, costly, and fruitless efforts to remove what now were found to be non-existing defects. In some instances even the reputation for accuracy of able astronomers had been clouded by such inexplicable discordances in their work, which, in the light of the new discovery, now prove only the evidences of the faithfulness and accuracy of these observers. Again, as to the constant of aberration, on which depends one important method of determining the distance of the



MOVEMENT OF EARTH'S AXIS, 1899 TO 1906.

sun (that great astronomical quantity on which all the conclusions as to the distances, masses, and other elements of the solar system hang, together with all the exact predictions depending on solar theory), it proves that the determinations of this important constant are sensibly affected by the variations of latitude.

Prof. Turner, in his Astronomical Discovery, has the following passage indicating still another possible effect of the wandering of the pole:

"If the axis of the earth is executing small oscillations of this kind, there should be an effect upon the tides; the liquid ocean should feel the wobble of the earth's axis in some way; and an examination of the tidal registers showed that there was, in fact, a distinct effect. It may cause some amusement when I say that the rise and fall are only a few inches in any case, but they are unmistakable evidences that the earth is not spinning smoothly, but has this kind of unbalanced vibration, which I have compared to the vibrations felt by passengers on an imperfectly engineered twin-screw steamer. A more sensational effect is that apparently earthquakes are more numerous at the time when the vibration is greatest. We remark that the vibration waxes and wanes much as that of the steamer waxes and wanes if the twin screws are not running quite together. Now, the passenger on the steamer would be prepared to find that breakages would be more numerous during the times of vigorous oscillation, and it seems probable that in a similar way the little cracks of the earth's skin, which we call great earthquakes, are more numerous when these unbalanced vibrations are at their maximum; that is to say, about once every seven years. This result is scarcely yet worthy our complete confidence, for our observations of earthquakes have only very recently been reduced to proper order; but if it should turn out to be true, it is scarcely necessary to add any words of mine to demonstrate the importance of this rather unexpected result of latitude variation."

The existence of the two principal factors in the variation of latitude, substantially as discovered by Mr. Chandler, are fully confirmed by the observations of the international latitude stations which have now been continued for six years. The period of the principal one is at present thought to be 437 days, however. The accompanying figure shows in a graphical form exactly how the earth's axis has been wobbling within the earth in these last six years. It is taken from a recent paper on the subject by Prof. Th. Albrecht, who, with Dr. B. Wanach, has reduced and published the international observations. In the figure the scale of motion is indicated in seconds of arc, which can be translated into feet or meters by remembering that one second of arc at the pole is about 100 feet, or 30 meters, so that the diameter of the larger curves is about 40 feet, or 12 meters. The time is indicated in years and tenths of a year by the figures adjoining the curves themselves. Thus, beginning with 1899.9 the curve passes over the years 1900, 1901, etc., and ends at 1906.0. It is plainly shown by this irregular curve what an apparently lawless wobble of the earth's axis is produced by the joint action of two periodic factors, one of about 437 days and one annual, the first of constant and the second of variable amplitude. Since 1890 it has been found that five of the long periods are almost exactly equal to six of the shorter, so that the whole movement nearly repeats itself every six years. It is interesting, though not conclusive, to note that the severe earthquakes of 1906 occurred soon after the time of maximum activity of the pole, which accords with the hypothesis touched upon by Prof. Turner, as already cited.

THE USES OF CALCIUM IN ALLOYS.*

By ARTHUR E. PRATT.

CALCIUM is a silvery white metal readily oxidized in moist air. It is very light (sp. gr. 1.52), fairly malleable, has a high specific heat, and is a good conductor of electricity. It is about as hard as aluminium, but at 400 deg. C. becomes as soft as lead. It is volatile, and can be sublimed *in vacuo* between 700 deg. C. and 800 deg. C., and melts at the latter temperature. It is a very powerful reducing agent.

The chief effects of alloying calcium with other metals are to produce brittleness, crystallization, and hardness; to promote oxidation and disintegration on exposure to air; to confer the power of decomposing water and in other ways increasing the chemical activity.

The author's experiments confirm Roberts-Austen's observation that the presence of small amounts of metals of high atomic volume will cause deterioration of the physical properties of metals of low atomic volume. The atomic volume of calcium is high (25.4), and the effect of small amounts on other metals is decidedly prejudicial, provided that the metals in question are pure. The experiments were conducted in a converse manner to Roberts-Austen's, i. e., the constant was a metal of high atomic volume (calcium) instead of being low (gold). In the course of the work the following observations were made: When an alloy is made of calcium and some metal which possesses a chemical property in common with it, an increased activity in the manifestation of that property is noticed in the alloy. This increase appears to be greater than would be obtained by the simple admixture of a more active metal, the presence of calcium usually increasing the activity of the other metal. In some cases the alloy is more active than either of its constituents.

Further, the chemical properties of calcium appear to be more pronounced in an alloy with a metal having an atomic value closely approaching that of calcium than they are in an alloy of the same percentage with a metal having a much lower atomic value. The two metals in question should be about equally active when unalloyed in the particular property with respect to which they are to be compared. It is probable that both these principles are general, and not confined to calcium, although more extended research on these lines would be desirable.

The most promising applications of calcium are as a reducing agent and for the refining of metals. In the latter case it acts in three distinct ways: (1) By reducing oxides and sulphides; (2) by eliminating dissolved gases; (3) by forming compounds with certain impurities, thus rendering them less deleterious. All three modes of action are strikingly shown in the case of copper. A suitable addition of calcium will remedy "dry" or "sulphury" copper, give a sound casting, and give a soft and tough ingot with prohibitive proportions of bismuth or antimony, besides restoring ordinary over-poled copper to tough pitch. If excess of calcium is present, however, it induces brittleness on its own account. With one or two doubtful exceptions, no alloy of calcium has shown any promise of commercial utility so far as physical properties are concerned, its only likely application in this direction being its hardening property.

* From a paper read before the British Association.

SCIENCE NOTES.

In all previous attempts to determine the position of the solar apex, or the point toward which the sun is moving, no regard has been put to the possibility that the sun may be one of a stream of stars moving in the same direction and with equal velocities. Prof. Kobold, of the observatory of Kiel, has become convinced by his studies of star currents that the sun actually does form part of such a current, which is moving toward a point on the edge of the Milky Way, with a right ascension of 18 hours 20 minutes and a declination of 0 deg. 2 min. south. This is very different from the result of the last previous determination, made by Newcomb in 1899, which gives the solar space right ascension of 18 hours, 30 minutes, and a declination of 35 deg. north.

The fact is now established that uranium is the primary source of the supply of radium. The recent discovery of ionium by Boltwood serves to link uranium with radium, and explains why it was that those who sought for radium as the immediate offspring of uranium found the latter apparently unproductive, the actual relation of uranium to radium being that of grandparent. But even were we without this connected knowledge, the fact of the invariable occurrence in nature of these elements, not only in association but in a quantitative relationship, can only be explained on a genetic connection between the two. This evidence, mainly due to the work of Boltwood, when examined in detail, becomes overwhelmingly convincing. Thus it is to uranium that we look for the continuance of the supplies of radium. In it we find an all but eternal source. The fraction of this substance which decays each year, or rather is transformed to a lower atomic weight, is measured in tens of thousands of millionths; so that the uranium of the earth one hundred million years ago was hardly more than one per cent greater in mass than it is to-day.

M. Gauckler, the eminent French archæologist who has been making excavations on the Janiculum at Rome, has unearthed some valuable relics. Under his direction Messrs. Nicole and Darier uncovered one of the chapels of a Syrian sanctuary. It is a rectangular cella which has an apse at the rear part containing a niche. In the latter is still found a divinity seated on a throne, no doubt a Syrian Jupiter. The statue covered a small assuary hollowed in the soil of the niche and containing part of a human skull. The presence of the skull in this place has not well been explained. In the center of the small temple is a triangular altar whose front face is hollowed in half-moon fashion. The threshold of the chamber had been restored and is composed of an altar slab of white marble. It carries an inscription dating 186 A. D. with the names of Gaionas and Aeflanius Martialis. These discoveries are of a great importance as being a contribution to our knowledge of ancient Rome especially as regards the existence of a group of buildings in an almost unexplored quarter which have a bearing upon the history of religions.

The Astronomer Royal for Scotland, Prof. F. W. Dyson, F.R.S., communicated a paper on a fascinating problem, "The Systematic Motion of Stars," to the British Association for the Advancement of Science. Kapteyn, of Gröningen, he said, had come to the conclusion that the stars drifted in two directions; that conclusion was based upon the examination of 2,500 stars, observed repeatedly since Bradley's days. In a similar inquiry, leading to similar results, Eddington had dealt with 4,000 stars within 52 deg. of the North Pole. Dr. Dyson's own analysis concerned 1,800 stars, of both the northern and the southern hemisphere, with comparatively large proper motions of more than 20 seconds in a century, and was based upon Groomidge's catalogue, the Cape catalogues, and Porter's Cincinnati catalogue. He had computed the angles between the proper motion of each star and the direction of two apices, and he had found that 1,100 of his stars were moving in a direction within 60 deg. of one apex, 600 within 60 deg. of the other apex, and 100 were outside these limits; the motions of these latter stars were irregular and apparently not directed to any particular point of the sky. The number of stars moving toward the second apex did not appear to be in accordance with Eddington's determination, and the evidence did not support the conclusion that the velocity of the first stream was three times greater than that of the second stream. On Prof. Dyson's diagram the displacement of a dot represented the projected proper motion of a star in a century. It seemed to be clear that the stars of large proper motion drifted toward two points; but there was a difficulty in the explanation of this being due to the existence of two streams. Mr. A. S. Eddington, of Greenwich Observatory, in commenting upon the paper, thought that the inequality in the number of stars might be explained by the omission by Dyson of stars of small proper motion; but he also considered that his own conclusion might ultimately require modification. Prof. Dyson replied that he himself anticipated finding a very much larger proportion of stars with large proper motions in the first group.

ENGINEERING NOTES.

There are over 800,000,000 cross-ties in service in the United States according to an estimate made by the Forest Bureau, and it is figured that 100,000,000 were consumed in new track and renewals made during the year 1906. An average life of a tie is but seven years, although with preservative treatment, and an equipment designed to lessen wear, a cross-tie may be made to survive fifteen years. Under present conditions it is estimated that to maintain each tie now in service two trees must be growing.

Notice has recently been given by the Suez Canal Commissioners that vessels drawing 28 feet of water are now permitted to pass through the canal. Hitherto the limited draft has been 27 feet; the minimum depth in the canal is now between 30 feet and 31 feet, as compared with 26 feet 3 inches when the canal was first opened. The canal has been successively deepened from 1884 to the present time. In 1898 it was 28 feet and in 1902 29 feet 6 inches; work is now in progress to obtain a minimum depth throughout of 34 feet 6 inches, but it is not expected that this depth will be realized before the end of 1912. The progress may be summed up as follows: Prior to 1884 the maximum draft for ships permitted in the canal was 24 feet 6 inches; in 1901, 25 feet 7 inches; in 1906, 27 feet; it is now 28 feet, and probably next year the limit will be increased to 30 feet.

The test of a high-speed engine, according to the Journal of the American Society of Mechanical Engineers summarized in Engineering News, shows a noteworthy economy and mechanical efficiency in consideration of the condition and length of service of the engine. The engine tested was a 7 x 7-inch American Blower Company engine used for driving a fan and had been run almost continuously day and night for 10,000 hours. The cylinder had been badly scored and the mean diameter increased to 7.082 inches. The piston had been worn small, showing a decrease of 0.013 inch in mean diameter, and the piston rings had been broken. Before making the test, the valve was set for equal cards and new piston rings put in. At full load and 430 r. p. m. the water rate was 41 pounds per indicated horse-power-hour. The indicated friction horse-power was 1.18 or 4 per cent of the indicated horse-power at full load. These results compare very favorably with those obtained with new engines of the same size and type.

According to Elektrotechnik und Maschinenbau, some time ago two turbines of the Parsons type, equipped with surface condensers and coupled to single-phase generators, were installed in the municipal electricity works at Frankfort. Tests have recently been made on these machines with the following results: Power on the electrical side was measured with an accurate wattmeter standardized by the Reichsanstalt, while the steam consumption was determined by weighing the condensed water. The temperature of steam on no occasion fell below 258 deg. C. At full load—3,521 kilowatts—with a steam pressure of 10 atmospheres and a 73.3 centimeters vacuum, the steam consumption was 13.7 pounds per kilowatt hour. At something less than half load—1,542.5 kilowatt—a steam pressure of 9.9 atmospheres and a 74.1 centimeter vacuum, the steam consumption was 15.6 pounds per kilowatt hour. The speed of the turbines was 1,360 revolutions per minute. The condensing machinery took at full load 2.9 per cent and at half load 2.5 per cent of the dynamo output.

The representative of a British firm making a specialty of securing factories and factory sites for applicants is quoted to the effect that many applications have been received from foreigners, induced thereto by the provision of the new law requiring articles patented in the United Kingdom to be manufactured there. An important feature of the applications already made is that the manufacturers demand works much larger than are necessary to make the patented article, giving as the reason that they can not run works in England on the patents alone, and therefore intend to make other goods which have hitherto been imported ready-made. Consequently, the volume of new manufacturing business brought to Great Britain is expected vastly to exceed what is directly attributable to the influence of the new law. It is stated that nearly 2,000 patents are now within the scope of the law, and if these were all manufactured in that country, 30,000 to 40,000 people would be given employment. The law became operative August 28, 1908. Thirty foreign firms had then completed arrangements to open factories in Great Britain. Among them are a number of American firms. Many firms in the United States and in Germany have negotiations for factories or sites under way. The principal articles made by the American firms are wire cloths, telephone implements, shoes, typewriters, and phonograph records.

TRADE NOTES AND FORMULÆ.

Stain for Oak.—80 parts of dry carbonate of soda, 250 parts of light ocher finely prepared, and 2,000 parts of rain water are boiled for half an hour, then 2,000 parts more of water are added. To this stain add 700 parts of mass, consisting of 1,000 parts of wax, 2,000 parts of water, and 70 parts of potash, after which it is boiled and stirred until cold.

Label Varnish.—125 parts gum sandarac and 125 parts of mastic are pulverized and mixed with 125 parts of powdered glass, over the mixture 125 parts of sulphuric ether are poured and then 500 parts of alcohol added. Solution is effected by agitation, without the application of heat, and the liquid is then filtered. If it is desired that the varnish shall have an agreeable odor a few drops of oil of lavender may be added.

Casehardening.—Iron is plunged red hot into a mixture composed of the following materials: 1,000 parts ferrocyanide of potassium, 2,000 parts rock salt, 2,500 parts of bone dust, 200 parts charcoal, and 500 parts hydrochloric acid. The metal is then to be heated again, placed again for a few minutes in the mixture and finally, while still hot, immersed in cold water. The quantitative proportions of the substances may be varied and in some instances some lime may be added.

Etched Ivory Work.—Cover the surface with a thin rosin varnish, transfer the design to this and etch it out very thoroughly with a sharp needle. Proceed then exactly as in the case of metal or stone etching; that is, build a wall of modeling wax about the surface to be etched and pour on the acid which, in the case in question, must be composed of 1 part sulphuric acid, poured in 5 to 6 parts of water and which works very rapidly. The lines are thereby turned a deep black. If we prefer brown lines dissolve 1 part of lunar caustic (nitrate of silver) in 5 parts of water, etch for a short time and then expose the object for several hours to the light until the lines have turned brown.

Finishing Preparations.—I. By Ducket and Mercer: 1 part sulphate of iron, 0.25 part sulphate of zinc, 0.5 part fish glue, 1 part Marseilles soap, and 0.5 part of spermaceti are dissolved in boiling water and to this 0.5 part of ultramarine and 0.5 part of soda added. To this mixture add 4 parts of paraffine and 2 parts of tallow and finally thicken with 80 parts of flour and 320 parts of water. II. By Chalimin: 16 parts of starch, 16 parts of wheat flour, 12 parts potato starch, 1.5 part of sulphate of zinc, 0.125 part of blue vitriol, 300 parts of water, 0.5 part of white wax. III. By Looke: 10 parts starch, 10 parts sago flour, 7.5 parts of rice flour, 3 parts of glue, 240 parts of water. IV. Crasse's: 125 parts of flour, 0.5 part of tallow, 1 to 2 parts of paraffine, 0.5 part potash. V. By Kean and Gabbot: 3 parts linseed oil, 3 parts hide trimmings, 0.5 part of alum, 114 parts of water, 110 parts of China clay. For light finish: 125 parts of wheat flour, 7.5 parts of tallow, 5 parts Marseilles soap; the flour is stirred into the water and left to ferment, the tallow and soap are boiled by themselves and then added to the fermented flour. For medium finish: 24.5 parts of wheat flour, 4.5 parts of tallow, 0.25 part of paraffine, 2.5 parts of Marseilles soap, hard, 0.5 part of soft soap, 11 parts China clay. In preparing this the wheat flour is mixed with water and allowed to ferment and the remaining materials, after they have been reduced to a fluid condition in a kettle, are added to the flour. Heavy Finish.—20 parts of wheat flour, 67 parts of China clay, 12 parts of tallow, 7½ parts of chloride of magnesia, 6 parts of chloride of zinc. Flour, water, and chloride of zinc are boiled together and after boiling the other ingredients, which have been separately boiled, are added. Very Heavy Finish.—14 parts fermented flour (mixed with rice flour), 22 parts of China clay, 11 parts sulphate of magnesia, 2.5 parts of tallow, 4.5 parts chloride of magnesia, 5 parts chloride of zinc.

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